

**Perspectives on climate change:
Understanding how climate change will affect dairy, arable and sheep
producers within Mid-Canterbury, New Zealand**

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Abstract

New Zealand's agricultural sector is susceptible to environmental, political, economic and institutional changes. A specific challenge for the sector is climate change. Climate change is likely to pose challenges and opportunities that agricultural producers will have to respond and adapt to in order to remain profitable. This thesis examines how climate change will affect dairy, arable and sheep producers within Mid-Canterbury. The study area has a diverse and productive agricultural sector, and this has been facilitated by the environmental setting and use of irrigation. A case-study methodology and semi-structured interviews were used to investigate how climate change will affect producers.

The findings of this research identified that farmers are sensitive to and exposed to multiple climatic and non-climatic sources of exposure, and this can make it difficult to adapt to climate change. The research also indicated that farmers perceived climate change in different ways. In general, understanding the causes of climate change did not encourage the use of adaptive measures. Awareness of how climate change could impact one's farming practice motivated the use of adaptive measures including water efficiency measures and changing the timing of activities. Farmers within Mid-Canterbury employed a range of short-term and medium-term adaptive strategies that were in response to a climatic condition or event, but also to ensure productivity and economic returns. The research also indicated that many different actors have a role in adaptation and the use of long-term strategies can be facilitated by industry groups and supplier. These can act as boundary organisations who can influence behaviours, improve awareness and help develop relationships between different actors. Overall, this study provides insights into how climate change will affect agricultural producers in Mid-Canterbury, and how adaptation can be facilitated.

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“What I know for sure is that speaking your truth is the most powerful tool we all have”

- Oprah Winfrey

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Chapter One: Introduction

“And no challenge poses a greater threat to future generations than climate change”

- Barack Obama, 44th President of the United States of America

1.0. Introduction

Mid-Canterbury is located on the east coast of the South Island of New Zealand, as seen in Figure 1.1. The climate in this area, despite its variability, provides a predictable growing season to farmers and makes the area well-suited for agriculture (Macara, 2016). Agricultural activities within the region have traditionally focused on sheep and arable farming practices; in more recent years, irrigation has supported the growth of the dairy and specialist crop and seed sectors (Ashburton Zone Committee, 2011). Sheep, arable and dairy farming continue to provide valuable employment and economic opportunities in the district (Infometrics, 2016). Dairy and arable farming practices are located across the Canterbury plains and are reliant on water from precipitation and irrigation. Arable farmers are also sensitive to extreme events including wind, rain and hail. In contrast, sheep farms are rarely irrigated and are predominantly located on marginal and hilly land in Mid-Canterbury's high-country (Evans, 2004). Each farm system is sensitive and exposed to a range of climatic factors, and this is also variable relative to their location. It is likely that climate change will have implications for agricultural producers. Mid-Canterbury provides a valuable study opportunity to examine how climate change will affect dairy, arable and sheep farming practices in Mid-Canterbury, New Zealand.

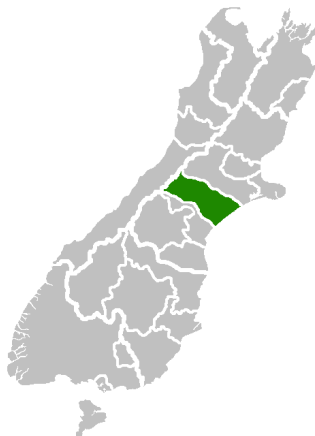


Figure 1.1. Location of Mid-Canterbury (Mapsof.net, 2018)

Climate change in the next 30 years is projected to increase average temperatures, the severity of extreme rainfall and drought events, alter precipitation patterns and exacerbate weather variability; these changes are likely to affect agricultural producers in Mid-Canterbury (Ministry for the Environment, 2016). Therefore, agricultural producers may need to adjust their practices to ensure they remain productive and profitable. Farmers are also required to alter their practice relative to changes in the economic, institutional, political, financial and environmental context, and these often need immediate attention (Cradock-Henry, 2017). As a result, it can be difficult to adapt to changes in climate as farmers are responding to other and more urgent challenges. There is currently limited information seeking to understand how climate change will affect dairy, arable and sheep producers in Mid-Canterbury, thus providing a valuable study opportunity.

Climate change for this thesis includes both anthropogenic and natural induced changes. Differentiating between the two remains difficult due to the significant effect of ocean-atmospheric circulation patterns on New Zealand's climate (Dean & Stott, 2009). Since 1750, the concentration of greenhouse gases has increased to unprecedented levels due to increased transport, industrial and agricultural emissions (Stocker et al., 2013). The rate greenhouse gases are added to the atmosphere has accelerated since 2000, and despite efforts to curb emissions, concentrations have continued to rise (Stocker et al., 2013). Increased greenhouse gas concentrations alter the atmospheric composition and the amount of radiation trapped in the lower atmosphere which poses a warming effect on the climate (Stocker et al., 2013). Natural influences occur on timescales varying from millions of years to a couple of years and include the Milankovitch Cycles, sunspot cycles, volcanic eruptions and ocean-atmospheric circulations (Melieres & Marechal, 2015). It is likely that anthropogenic contributions have been the dominant cause of current climate change and greenhouse gases emissions must be reduced to prevent dangerous impacts (Stocker et al., 2013).

In New Zealand, approximately 48% of greenhouse gas emissions are from the agricultural sector. This is unique when compared to other developed countries where agriculture only accounts for approximately 12% of emissions (Ministry for the Environment, 2017b). The dominance of agricultural emissions means the main greenhouse gases emitted are methane and nitrous oxide which have high global warming potential in comparison to

carbon dioxide. New Zealand's emissions profile has made it difficult to reduce emissions, and gross emissions have increased by 24.1% since 1990 (Ministry for the Environment, 2017b). The Emissions Trading Scheme (ETS) is a market-based policy instrument utilised in New Zealand. It provides an option for climate change mitigation by aiming to reduce emissions through putting a price on greenhouse gases and encouraging activities that sequester carbon dioxide. However, the ETS excludes agricultural emissions because there are limited cost-effective mitigative options available to reduce these. Nonetheless, there has been multiple investments into research institutions seeking to find ways to reduce agricultural emissions (Biswell, 2015; Leonard, 2015).

Although reducing emissions is challenging, New Zealand has ratified international climate agreements that recognise the need to mitigate and adapt to climate change, including the United Nations Framework Convention on Climate Change, the Kyoto Protocol and the Paris Agreement (Leonard, 2015; Ministry for the Environment, 2017b). The Paris Agreement seeks to limit the increase in global average temperatures to well below 2.0°C and requires each country to adopt a target to reduce emissions that reflects the country's capabilities (New Zealand Government, 2015). Under the Paris Agreement, New Zealand has committed to reducing emissions by 20% of 2005 levels by 2030 (New Zealand Government, 2016). Many countries have failed to make significant reductions and the domestic policy tools utilised have been inadequate (Leonard, 2015). As New Zealand only contributes 0.17% of total global emissions, it is often thought that there should be minimal pressure to reduce emissions due to their small contribution (New Zealand Government, 2016). However, it is critical that New Zealand upholds its responsibility designated in these agreements to maintain the national image as being 'clean and green' and '100% pure' (Parliamentary Commissioner for the Environment, 2016b). Primary producers and exports have thrived off this image, and as many primary products are becoming substitutable in the international marketplace it is more critical than ever to maintain this image.

The difficulty in mitigating climate change means some climatic changes have been committed to even if all emissions of GHGs are suddenly stopped (Armour & Roe, 2011; Stocker et al., 2013). Changes in climate are likely to affect agricultural production through changes to the timing of seasons, water and irrigation reliability, drought risk and

feed availability (Bright et al., 2011; Clark et al., 2012; Lieffering, Newton, Li, & Vibart, 2012). For agriculture to be profitable, a suitable climate is necessary. Farmers are generally adaptable to small deviations outside the average climate. However, more significant changes to average conditions and extreme events are more difficult to respond and adapt to (Salinger & Griffiths, 2001; Gornall et al., 2010). Climate change will pose both opportunities and challenges for agricultural producers. This will be dependent on the response to the change in climatic condition. Adaptation provides options for systems, institutions and humans to adjust, manage and respond to climatic challenges and opportunities (Intergovernmental Panel on Climate Change, 2014). The use of adaptive measures is affected by how changes in climate are perceived, vulnerability and adaptive capacity (Perez, 2003; Niles & Mueller, 2016). Adaptive capacity and vulnerability are also influenced by the prevailing social, environmental, economic, regulatory, political and physical environments which farmers operate within.

In Mid-Canterbury farmers also respond changes in global demand and consumer preferences, regulatory requirements, interest rates and legislation amongst other changes. This makes agriculture a multi-risk and multi-opportunity industry and these changes can make responding to climate change more difficult as there are other pressing and more immediate challenges that require changes to systems (Cradock-Henry, 2017). Mid-Canterbury has a variable climate and rainfall is distributed randomly throughout the year; farmers have been adaptable to this variability (Macara, 2016). However, it is unknown whether this variability will allow farmers to cope with changes outside the current range of extremes and average conditions. Mid-Canterbury is a significant contributor to agricultural exports, and agriculture in New Zealand directly accounts for 4% of the Gross Domestic Product (GDP). The processing of food, beverages and tobacco products account for a further 4% (The Treasury, 2016). Due to its importance, it is essential to understand how climate change will affect agricultural producers.

Climate change is a wicked problem and requires changes in behaviour to avoid, remedy and mitigate adverse effects (Head, 2014; Perry, 2015). Climate change is often viewed as a polarising topic and scepticism can surround the issue, which can mean changing behaviours is difficult. This is exacerbated by the fact that agricultural producers are continually responding to changes in the prevailing context that affects their farming

practice. It is critical to understand how farmers can respond to climate change, and how this is affected by their perception of this issue. It is also valuable to recognise what farmers view as opportunities and challenges, their adaptive behaviours and the contextual factors that may affect their ability to respond to climate change. Mid-Canterbury has been able to prosper due to agriculture, therefore, is adaptation to climate change necessary for the district to continue to thrive? Do agricultural producers within Mid-Canterbury have the capacity to adapt to climate change? It is hoped that this thesis will provide a greater understanding of how climate change will affect dairy, sheep and arable agricultural producers within Mid-Canterbury through understanding their adaptive behaviours.

1.1. Research objectives

The overarching purpose of this thesis is to understand how climate change will affect dairy, arable and sheep farmers in Mid-Canterbury through examining perceptions of climate change. Perceptions provide insights into climatic challenges and opportunities, adaptive responses and other contextual factors farmers warranting a response from farmers. This provides information about the vulnerability and adaptive capacity of an area through understanding the perceived susceptibility to harm and the ability and need to utilise adaptive measures. The thesis seeks to answer the question: *how will climate change affect dairy, sheep and arable farming practises in Mid-Canterbury?*

To achieve this, four research objectives have been developed:

- Understand present and future climatic challenges and opportunities for agricultural producers in Mid-Canterbury.
- To understand the context farmers, operate within and are affected by.
- Understand how agricultural producers perceive climate change.
- Identify adaptive measures that have been or could be adopted.

A case-study methodology was used to achieve these objectives. This method utilised semi-structured interviews to provide a rich understanding of a 'case'. In this research, the case is considered in three ways including Mid-Canterbury as a region, each farming industry, and each individual farmer. The thesis will provide an understanding of how climate change will affect agricultural producers in an area that has not been studied but is

valuable for agriculture. It also seeks to provide an understanding of the differences and commonalities between and within different agricultural industries. Finally, it aims to develop the use of semi-structured interviews to understand farmer perspectives.

1.2. Study area: Mid-Canterbury

Mid-Canterbury covers 6,175km² and extends from the Rakaia River in the north, to the Rangitata River in the south, and from the main divide to the sea. It is situated in the middle of Canterbury province and the main urban centre is Ashburton. Within the district, natural resources such as rivers and lakes are used for various recreation, economic and cultural purposes (Ashburton Zone Committee, 2011). Figure 1.2. provides an aerial photograph of Mid-Canterbury; the two visible rivers designate the boundaries of the area.



Figure 1.2. Aerial photograph of Mid-Canterbury (Google, 2018)

The natural environment including fertile soil, flat terrain and availability of water has facilitated the development of agriculture within Mid-Canterbury. The development of irrigation and the high cost of such systems has changed the distribution of farming activities across the district. Sheep farming is now predominantly confined to marginal high-country land that is not irrigated. This is because the annual income of a sheep farmer is generally not sufficient to warrant the investment and use of irrigation (Chalmers, 2014).

The plains are more effectively utilised by dairy and arable practices which have benefited from the use of irrigation and a reliable source of water (Ashburton Zone Committee, 2011). These sectors continue to be of importance in Mid-Canterbury, and agriculture and the associated services and processing activities contribute 34% towards the area's GDP and employs 35.5% of the population (Infometrics, 2016). This has facilitated population and economic growth in the region and is dependent on a continued reliable supply of water (Ashburton Zone Committee, 2011).

The climate experienced in Mid-Canterbury is critical for agricultural producers, and farmers have been highly adaptable to the variable rainfall patterns within the district. Irrigation has also been fundamental in managing this variability. (Ward & Russel, 2010; Ashburton District Council, 2016). Climate change is projected to increase average temperatures in Mid-Canterbury (Bright et al., 2011). Precipitation may increase by up to 400mm in the headwaters and little change is projected on the plains (Bright et al., 2011). An increase in evaporative demand, drought and heavy rainfall events is also likely (Sansom & Renwick, 2007; Reisinger, Mullan, Manning, Wratt, & Nottage, 2010). These changes will affect agricultural producers and will require them to adopt adaptive measures to utilise opportunities and minimise challenges that are posed because of these changes.

Farmers in Mid-Canterbury are adaptable to the variable climate that exists. However, the ability to adapt to changes in average conditions and extreme events is unknown. As the district is dependent on agriculture, it is critical to assess the implications of climate change on agricultural producers within this area. Mid-Canterbury provides a unique opportunity for a case-study that will provide further information about how climate change will affect different agricultural sectors in an area with a variable climate, susceptible to droughts and reliant on irrigation.

1.3. Thesis structure

The overall aim of this research is to assess how climate change will affect arable, dairy and sheep farmers in Mid-Canterbury by understanding the context affecting farmers, the current and future climatic challenges and opportunities, and farmers' perceptions of

climate change. These factors affect adaptive capacity, vulnerability and the adoption of adaptive measures.

This chapter has introduced the topic, the research objectives and provided a brief description of the study area. Chapter Two presents the conceptual context and the foundations of the research. The methods used to understand how climate change affects agricultural producers are introduced as the research context. Subsequently, the concept of adaptation will be reviewed and is revealed to be a fundamental component to assess how climate change will affect agricultural producers. Adaptive capacity and vulnerability are examined as they determine the ability and need to respond to climate change (Engle, 2011). Perceptions of climate change also influence the use of adaptive measures. Finally, the use of qualitative methods to understand these components is introduced. Qualitative studies provide insights into behaviours and what affects the utilisation of adaptive strategies; this cannot be easily captured by quantitative methods.

Chapter Three identifies contextual factors that affect farmers within Mid-Canterbury. This includes the environmental and physical setting including the soils, water and climate of the area. The economic, political and institutional forces are also introduced. Finally, the history of Mid-Canterbury and dairy, arable and sheep farming practices within the area are discussed. This chapter helps to achieve the fourth objective and identify the contextual factors operating in Mid-Canterbury.

The methodology used in the research is described in Chapter Four. This includes the literature review as fundamental in the development of the study. Qualitative research approaches are then introduced. Qualitative research provides an opportunity to understand peoples' experiences, opinions and values; they yield insights into the social world and adaptive behaviours which cannot be captured by quantitative methodologies. Chapter Four incorporates an account of the qualitative approach and method used in this research. The research process and myself as a researcher are also reflected on. Latent content analysis, the process used to analyse the data collected is then described.

Chapter Five provides the results of the research, and helps to achieve the objectives of the thesis. This includes the predominant themes that emerged from the interview process. The

themes reveal the commonalities, differences and irregularities in perceptions of farmers, based on different characteristics or farm-type. This includes the identification of climatic challenges and opportunities, the specific contextual factors of concern for each farm type, adaptive measures used and perceptions of climate change. Chapter Six provides a discussion of the research findings and identifies how suppliers and industry groups can act as boundary groups to facilitate adaptation of agricultural producers. The final chapter concludes the research, the implications of the findings and suggests areas for further research.

Chapter Two: Understanding how agricultural producers adapt to climate change

“Climate change, that is a huge variable for farming, and we don’t really know, or understand what the effects of that could be”

- Dairy farmer, Mid-Canterbury

2.0. Introduction

Agricultural producers operate within a complex environment (Bryant et al., 2000; Smit & Pilifosova, 2003). They are faced with multiple challenges and opportunities, and it is likely climate change will present new risks and opportunities (Engle, 2011). Therefore, to continue to prosper, agricultural producers may have to adjust and alter their farming practices to accommodate these changes (Howden et al., 2007; Kenny, 2011; Cradock-Henry, 2017). Top-down computer-based model assessments have been used to identify how the likely changes in climate will affect agricultural producers and suggest adaptive measures that could be utilised. These studies have failed to recognise that adaptation is not a linear process and varies relative to the context farmers operate within, their vulnerability, adaptive capacity, perceptions of climate change and individual characteristics (Bryant et al., 2000; Smit & Pilifosova, 2003; Engle, 2011).

More recently, qualitative methods have been used to understand how the context operating affects decision-making, vulnerability and the adaptive capacity of an individual, sector or locality, and thus the ability to implement adaptive measures (Kenny, 2011; Cradock-Henry, 2017). Vulnerability and the need to adapt can be reduced or exacerbated by the prevailing economic, institutional, political and environmental context (Adger, Arnell, & Tompkins, 2005; Kenny, 2011). These studies have also identified that the way climate change is perceived and the characteristics of an agricultural producer affect the willingness to adopt adaptive measures (Wilbanks & Kates, 1999; Niles & Mueller, 2016). Understanding these components is critical to comprehend the actual adoption and variability of adaptive options, and this helps to demonstrate how climate change may affect agricultural producers.

This chapter will provide the context for the research and the need for further inquiries seeking to understand how climate change will affect producers through understanding vulnerability, adaptive capacity, perceptions of climate change and the context affecting

decision-makers. It will then introduce adaptation and its characteristics. Following this, how vulnerability and adaptive capacity relate to adaptation will be examined. Subsequently, the influence of perceptions on the utilisation of adaptive measures will be discussed. Perceptions influence the adoption of adaptive strategies and therefore must be understood (Niles & Mueller, 2016). Next, the use of methods including qualitative methods to understand vulnerability and adaptive capacity and perceptions will be reviewed. Finally, the current research completed in New Zealand will be introduced to show the need for further studies. This chapter will provide information that allows an understanding of how climate change will affect agricultural producers to be developed.

2.1. Research context

2.1.1. Background

New Zealand's agricultural sector operates within a specific institutional, economic, political, social and environmental context (Adger et al., 2005; Pomeroy, 2015). The climate is one environmental component that influences the suitability of a farming practice in an area (Salinger & Griffiths, 2001). Climate is defined as the average and variability of weather patterns including precipitation, temperature and wind in a locality over time (Mathez, 2009; Cuevas, 2011). The climate is typically based on a 30-year record in an area (World Meteorological Organization, 2017). However, many localities do not have 30 years of data, so the available statistics in these locations may not capture cyclical weather patterns (National Institute of Water and Atmospheric Research, 2016).

Historically, farmers have successfully managed small changes in the climate, and this includes minor variations in average conditions (Salinger & Griffiths, 2001; Smit & Skinner, 2002; Adger & Vincent, 2005; World Meteorological Organization, 2017). Farmers are not as well adjusted to changes in the frequency and magnitude of extreme events, increased variability and more significant changes in the average conditions as projected with climate change (Salinger & Griffiths, 2001; Bizikova, Crawford, Nijnik, & Swart, 2014). Climate change will have implications for all aspects of life (Hansen et al., 1981; Howden et al., 2007; Armour & Roe, 2011; Kenny, 2011; Stocker et al., 2013).

The Intergovernmental Panel on Climate Change (2014) has defined climate change as, “a change in the state of the climate that can be identified by changes in the mean and/or variability of its properties, and that persists for an extended period” (p. 120). Climate change includes shifts in average conditions, increased magnitude and severity of extreme events and increased volatility. In considering this, climate variability must also be defined. Climate variability refers to variations in the average state and other statistics, including the frequency and magnitude of extreme events, and may include seasonal and inter-annual variations (Salinger, Renwick, & Mullan, 2001; Intergovernmental Panel on Climate Change, 2014). These natural variations are superimposed on the underlying trend of climate change. It is critical to differentiate between the two terms, but also understand that the two are related.

The projected changes and subsequent impacts of climate change vary relative to the timescale used (Ministry for the Environment, 2016). For this thesis, climate change includes considering the consequences that are likely over the next 20 to 30 years. Climate change may require the adoption of methods of adjustment that allow agricultural producers to continue to prosper over this period relative to the changing climatic conditions (Salinger & Griffiths, 2001; Smit & Skinner, 2002; Cradock-Henry, 2017).

2.1.2. Impact assessments

Climate change is likely to pose new opportunities and challenges to agricultural producers. Impact assessments and computer-based models have been used to understand this (Tait, 2008; Reisinger et al., 2014). These use the likely changes in climate and stimulate the implications of such changes including changes in economic return and productivity (Kenny, Warrick, Mitchell, Mullan, & Salinger, 1995; Warrick, Kenny, & Harman, 2001). The CLIMPACTS studies provided the foundations of these assessments in New Zealand (Kenny et al., 1995; Kenny et al., 2000). These studies utilised models to understand impacts at a regional-level to the prominent agricultural products at the time including orchards, kiwifruit and pasture production (Kenny et al., 1995; Warrick et al., 2001). These studies provided valuable insights into how climate change will affect agricultural production. However, they are now out-dated and do not present results that capture the current magnitude of changes and likely effects of climate change.

Various other studies in New Zealand have documented the potential impacts of climate change on different sectors or localities (Clark & Tait, 2008; Tait, 2008; Bright et al., 2011; Clark, Mullan, & Porteous, 2011; Teixeira & Brown, 2012). These studies have improved our understanding of the likely impacts that may affect agricultural producers in New Zealand. Effects include changes to the temperature, timing of seasons, precipitation, extreme weather events, drought duration, the spread of pests and carbon fertilisation (Kenny et al., 2000; Clark & Tait, 2008; Fowler, Aiken, & Maree, 2008; Tait, 2008).

Impact assessments and computer-based models are valuable to identify likely impacts. However, they use fixed inputs, and this does not account for the changing concentration of GHGs in the atmosphere (Sansom & Renwick, 2007; Reisinger et al., 2010; Ministry for the Environment, 2016). There has been increased efforts to capture different global scenarios of future emissions and likely changes in climate with the development of the Representative Concentration Pathways (RCPs) (van Vuuren et al., 2011). These are valuable as they identify a range of impacts that are likely relative to different emissions scenarios. However, they are still limiting as they may not capture the actual changes that occur, and therefore, there are some uncertainties relating to the projected changes. Computer-based models identify the likely impacts that will face agricultural producers but provide a simplified characterisation of reality and do not capture the changes that necessarily occur (van Aalst, Cannon, & Burton, 2008).

These studies had limited consideration about how adaptation can minimise the impacts of climate change. Adaptation is a fundamental component of understanding how climate change will impact agricultural producers because it provides options for adjustment that would allow farmers to respond to the challenges and opportunities that will occur (Kenny, 2011). Models and impact assessments have assumed adaptation consists of a linear sequence of events to future and identifiable sources of risk (Kenny, 2011; Manning, Lawrence, Chapman, & Ngaru King, 2015). However, as the likely impacts of climate change are not fixed; it cannot be assumed adaptation follows a linear trajectory (Kenny, 2011; Kalaugher, Bornman, Clark, & Beukes, 2013; Manning et al., 2015).

Impact assessments and models fail to recognise the importance of context on decision-making and other sources of risk that agricultural producers respond to. They also fail to

account for the actual adoption of adaptive measures and how the options perform in reality (Smit & Skinner, 2002). Impact assessments and computer-based models provide a limited assessment of how climate change will affect agriculture as they fail to consider the complexity of adaptation.

2.1.3. Qualitative inquiries

Qualitative inquiries have been used as a method to improve understanding of adaptation and can be complementary to computer-based models (Kalaugher et al., 2013). Qualitative studies have identified that the adoption of adaptive measures is influenced by the physical and environment setting, the political, institutional and economic context and this also shapes a farmers' vulnerability to climate change (Wilbanks & Kates, 1999; Cradock-Henry, 2008; Kenny, 2011; Manning et al., 2015). In contrast, computer-based models and impact assessments failed to consider the context that affects agricultural producers, and their ability to implement and adopt adaptive measures. Qualitative inquiries provide an opportunity to understand this.

The implementation of adaptive measures also varies relative to how a farmer perceives climate change, the associated opportunities, and challenges (Arbuckle, Morton, & Hobbs, 2015; Niles & Mueller, 2016). For example, farmers more concerned about climate change were more likely to employ adaptive measures (Kenny, 2011; Barnes & Toma, 2012; Arbuckle, Morton, & Hobbs, 2013; Niles, Lubell, & Brown, 2015). Model-based assessments do not consider this, and therefore, the impact of climate change on agriculture cannot be fully understood by such means alone.

The next part of this chapter will introduce the concept of adaptation and its characteristics; adaptation is critical to reduce the risks and utilise the opportunities posed by climate change (Smit & Pilifosova, 2001; Adger, 2006; Cradock-Henry, 2017). Following this, it will discuss vulnerability and adaptive capacity. It will examine the significance of understanding perceptions of agricultural producers, and how opinions have varied relative to specific characteristics of a farmer and farm type as these affect the utilisation of adaptive measures (Deressa, Hassan, Alemu, Yesuf, & Ringler, 2008; Jorgensen & Termansen, 2016). The use of qualitative methods to distil these components will be evaluated. Finally, the current research completed in New Zealand will be

introduced and will provide an understanding of why further studies are necessary. Throughout this chapter, the importance of understanding the context farmers operate within will also be emphasised, and this idea will be further elaborated in Chapter Three.

2.2. Adaptation

The definition of adaptation has varied in the disciplines it has been used in (Gallopín, 2006; Smit & Wandel, 2006; Meinke et al., 2009). Within the climate change literature, there have also been variations (Gallopín, 2006). Smit, Burton, Klein, and Wandel (2000) define adaptation as “adjustments in ecological-social-economic systems in response to actual or expected climatic stimuli, their effects or impacts” (p. 225). Brooks (2003) conceptualised it as “adjustments in a system’s behaviour and characteristics that enhance its ability to cope with external stresses” (p. 8). The Intergovernmental Panel on Climate Change (2014) defines adaptation as “the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities” (p. 118). All definitions consider adaptation as the process of adjusting.

2.2.1. Adaptation to what?

Adaptation occurs in response to a hazard, such as climate change. A hazard refers to “the potential occurrence of a natural or human-induced physical event or trend or physical impact,” and that may cause adverse impacts (Intergovernmental Panel on Climate Change, 2014 p. 124). Although a hazard is often perceived as an immediate impact, this definition acknowledges that it includes both events and trends, including extreme weather events and the gradual changes of climate change. Adaptation to climate change provides options to moderate or reduce the damage posed by climate change and to utilise the opportunities presented (Engle, 2011).

Bradshaw, Dolan, and Smit (2004) identified that the ability to manage extreme events, variability and changes in average climatic conditions improved with adaptation. Adaptation can reduce immediate risks and sequester benefits (Adger et al., 2005). Reilly and Schimmelpfennig (1999) highlighted that adaptive decisions are rarely made based purely on climatic stimuli and are affected by the economic, institutional, political, and

environmental context operating. This is because the context may influence what producers can do or they may require more immediate attention and investment than what climate change does. Therefore, although climate change is the focus of this research, it is essential to understand the context operating as this also affects the ability of agricultural producers to adapt to climate change.

2.2.2. *Characteristics of adaptation*

Adaptive decisions vary relative to spatial scale, actor, type, purposefulness, timing and temporal scope (Smit & Pilifosova, 2001). Adaptive measures are implemented on different scales from localised on the farm to wide-spread community initiatives (Bryant et al., 2000). Therefore, they are imposed by both private decision-makers including individuals, businesses, and groups, or public institutions such as regulatory bodies and governments (Bryant et al., 2000; Smit & Pilifosova, 2001). Smit, McNabb, and Smithers (1996) recognised measures imposed by regulatory bodies can govern what is feasible for an individual to implement.

The types of adaptive measures include structural, technological, financial, institutional, legal, practical and managerial options (Smit & Skinner, 2002). Some options require an individual actor to implement them on a small-scale. However, others need public institutions to develop measures at larger-scales, as seen in Table 2.1 (Smit & Pilifosova, 2001; Smit & Skinner, 2002; Bradshaw et al., 2004).

Table 2.1. *Example of actors in adaptation and types of adaptive measures*

Actor	Type	Example measure
Agricultural producer	Technological	On-farm resource management innovations
	Financial	Mechanisms that seek to improve efficiencies
	Managerial	Crop insurance investment Participate in government programmes Diversify income sources Diversify production and intensity Implement irrigation practices
Public institutions: regulatory bodies and government	Technological	Development of new crop varieties
	Administrative	Develop resource management innovation
	Institutional	Improvements in weather prediction systems Modify subsidy, support and incentive programmes

Note. Adapted from: Smit and Pilifosova (2001) and Smit and Skinner (2002)

The purposefulness and timing of adaptive measures are also critical to consider (Smit & Skinner, 2002). Purposefulness can be spontaneous and reactive, part of on-going management or planned in response to an anticipated risk or opportunity (Bryant et al., 2000; Smit et al., 2000; Smit & Skinner, 2002). Alongside this, decisions may provide long-term, medium-term or short-term options and usually, this differs relative to whether the option is anticipatory or reactive (Smit et al., 1996; Brooks, Adger, & Kelly, 2005). Niles et al. (2015) identified that whether options are anticipatory or reactive varies relative to how the opportunity or challenge is perceived by the actor implementing the measure.

2.2.3. Summary

It is critical to understand the different characteristics of adaptation. The implementation of adaptive options varies based on the prevailing context operating within an area (Smit & Skinner, 2002; Adger et al., 2005; Meinke et al., 2009; Wilk, Hjerpe, Yang, & Fan, 2015). These factors influence vulnerability and adaptive capacity, and thus, the need and ability to adapt (Smit & Wandel, 2006). How opportunities and risks are perceived also affects the implementation of adaptive measures (Niles, Brown, & Dynes, 2016; Cradock-Henry, 2017). Therefore, to understand how climate change will affect agricultural producers, the discussion needs to move beyond adaptation and consider the importance of vulnerability, adaptive capacity, and perceptions.

2.3. Vulnerability and adaptive capacity

2.3.1 Vulnerability

The conceptualisation of vulnerability has also varied in each discipline it has been used in (Kelly & Adger, 2000; Turner et al., 2003; Brooks et al., 2005). The Intergovernmental Panel on Climate Change (2014) describes vulnerability as the “propensity or predisposition to be adversely affected” (p. 128). Adger (2006) describes vulnerability as “the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt” (p. 268). Therefore, vulnerability relates to the need to adjust and adapt to minimise adverse outcomes (Kelly & Adger, 2000; Smit & Pilifosova, 2001).

Vulnerability is closely related to the concept **exposure-sensitivity** (Brooks et al., 2005; Smit & Wandel, 2006). Exposure relates to “the degree, duration, and/or extent in which a system is in contact with, or subject to, the perturbation” (Gallopín, 2006, p. 296). Sensitivity refers to “the degree to which the system is modified or affected by an internal or external disturbance or set of disturbances” (Gallopín, 2006, p. 295). Therefore, exposure-sensitivity refers to the likelihood of a system’s exposure to a risk, and the characteristics of the system which make it sensitive to the risk (Smit & Wandel, 2006; Engle, 2011). For example, a farmer dependent on irrigation is more exposed and sensitive to a reduction in water availability, than a farmer who is not as reliant on water resources (Clark et al., 2012). Therefore, the way vulnerability is experienced is not uniform over space and is highly dependent on the context operating.

A risk is a product of a hazard, population, and vulnerability (Brooks et al., 2005). The link between vulnerability and risk assumes that a decrease in the level of vulnerability will decrease the risk confronting the system (Brooks et al., 2005). Multiple risks must be responded to alongside climate change (Smit & Skinner, 2002). These include and are not limited to production or yield, price or market, institutional, human or personal and financial risks and are explained in Table 2.2 (Harwood, Heifner, Coble, Perry, & Somwaru, 1999; Hardaker, Huirne, Anderson, & Lien, 2004). Risks also relate to the prevailing context, and may be a product of a change in any of the contextual factors.

Table 2.2. *Different types of risk in agriculture*

Type of risk	Explanation
Production or yield risk	Losses in production and/or yield often because of the unpredictability of weather, or the introduction of new technology without a full understanding of the outcomes.
Price or market risk	Reflects risks associated with the changes in commodity prices or prices of inputs to agricultural production. Agriculture requires investments, with often late return periods.
Institutional risk	Results from changes in policies, regulations and rules that affect agriculture. May result in unintended impacts as result of changed constraints or costs on agricultural practices
Human or personal risk	Risk associated with those who run the farm, including the owner and staff, including life crises such as death, divorce and illness can cause disruptions in running the farm, as well as, changing individuals involved in activities on the farm may have impacts
Financial risk	This describes the way the capital is obtained and financed, and this may be subject to interest rates or face cash flow difficulties

Note. Adapted from: Harwood et al. (1999) and Hardaker et al. (2004)

Agricultural producers respond to multiple sources of risk including climatic stimuli and contextual arrangements (Harwood et al., 1999; Smit & Wandel, 2006; Engle, 2011). Therefore, vulnerability assessments only considering climate-related stimuli provide a limited assessment of how climate change will affect agricultural producers as the ability to adapt is influenced by other determinants (Kenny, 2011; Cradock-Henry, 2017).

Cradock-Henry (2017) identified that climate, including precipitation, temperature, variability and extremes, and the market were the dominant sources of exposure for kiwifruit growers in New Zealand. Tarleton and Ramsey (2008) also identified that there are multiple sources of risk agricultural producers respond to. Another study found that responses to year-to-year storms were variable relative to the different contextual factors and the variability of the specific storm (Kelly & Adger, 2000). It is paramount that in considering vulnerability, the context and other sources of risk are reviewed as this influences adaptation and help to illustrate how there are variations in vulnerability across space and time.

2.3.2. Adaptive Capacity

Adaptive capacity relates to vulnerability and the ability to modify exposures to risks, absorb and recover from losses and exploit opportunities that may become available as result of climate change (Smit & Pilifosova, 2003; Adger & Vincent, 2005; Smit & Wandel, 2006). It can be expanded or narrowed by local processes, and these are also affected by larger-scale economic and political forces (Adger et al., 2005; Smit & Wandel, 2006). This also means adaptive capacity is not evenly distributed across space and affects different sectors differently (Engle, 2011).

Adaptive capacity is influenced by access to economic resources, technology, information and skills, social capital, equity, institutions, infrastructure, and management as identified in Table 2.3 (Adger, 2003; Smit & Pilifosova, 2003; Brooks et al., 2005). Therefore, it is variable at different scales such as an individual, community, and country (Smit et al., 2000).

Table 2.3. *Determinants of adaptive capacity*

Influence	Explanation
Economic resources	The ability to implement measures may be dependent on the economic resources available
Technology	The availability and access to technological options
Information and skills	Awareness and knowledge about the available options and the means to implement these
Social capital	The social networks that influence the ability to work together
Equity	The fairness of the distribution of resources
Infrastructure	The availability and access to resources by decision makers
Management	The ability to manage risks

Note. Adapted from: Smit and Pilifosova (2001) and Adger (2003)

Adaptive capacity is also related to the coping range. The coping range refers to the range in which activities are not affected by changing conditions as seen in Figure 2.1, and it can be widened or narrowed by the operating context (Smit & Pilifosova, 2003; Smit & Wandel, 2006; Engle, 2011). In general, the annual and seasonal climatic conditions tend to stay within the coping range. Extreme events and variability may lie outside this range, and a producer or system may be vulnerable outside the coping range (Smit & Pilifosova, 2003; Smit & Wandel, 2006). Therefore, increasing adaptive capacity can widen the coping range and improve the ability to respond to climate change and variability (Smit & Wandel, 2006; Engle, 2011). Smit and Pilifosova (2003) identified that as changes become larger outside the coping range, it becomes progressively more difficult to adapt. Episodic and staggered investments in adaptive measures provide options to limit greater deviations outside the coping range (Smit & Pilifosova, 2003).

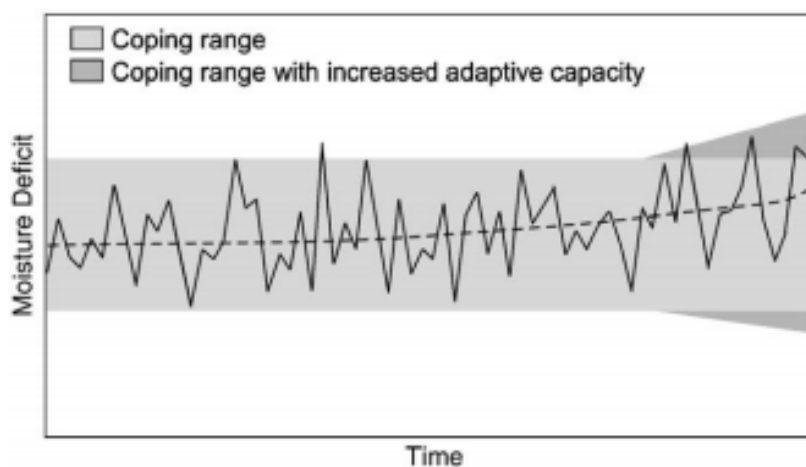


Figure 2.1. Coping range and extreme events (e.g. drought severity) (Smit and Wandel 2006, adapted from Smit and Pilifosova 2003)

2.3.3. Summary

Vulnerability and adaptive capacity are linked to adaptation. Vulnerability influences the need for adaptation, and adaptive capacity determines the ability to adapt. These are affected by the context operating and are not only a product of climate-related stimuli (Smit & Wandel, 2006). The following section will provide a summary of adaptation, vulnerability and adaptive capacity and the current research undertaken in this field.

2.4. Relationship between adaptation, vulnerability and adaptive capacity

The current discussion has revealed that adaptation, vulnerability and adaptive capacity are inherently related, and this is summarised in Figure 2.2, which was developed by Smit and Wandel (2006). Broad-scale determinants signify the large forces that affect adaptive capacity, exposure, and sensitivity including the institutional, political, economic, and environmental context (Smit & Wandel, 2006; Cuevas, 2011). The interaction of these aspects determines local-scale determinants as indicated by the smaller, embedded set of circles, and the adaptive capacity, exposure, and sensitivity (Cuevas, 2011). These factors influence vulnerability, and adaptation measures are an expression of adaptive capacity (Smit & Wandel, 2006). Although Figure 2.2 characterises the relationship between adaptation, vulnerability and adaptive capacity, the components are dynamic and always changing relative to the current context (Cuevas, 2011). Therefore, it is necessary that there are studies across time and space that seek to understand adaptive capacity, vulnerability and adaptation.

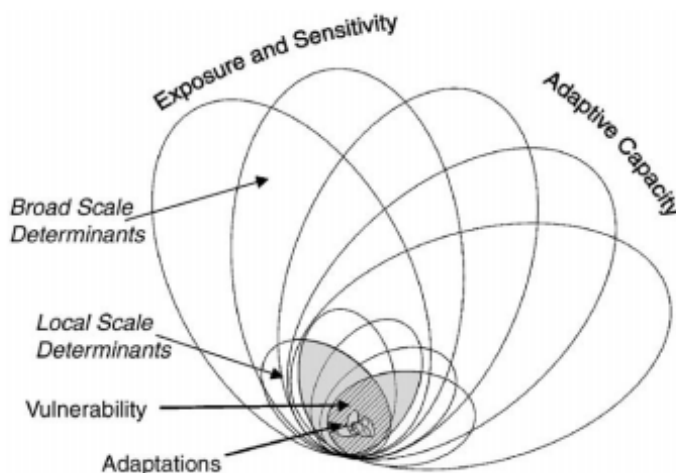


Figure 2.2. Conceptualisation of vulnerability (Smit & Wandel, 2006)

Studies seeking to understand adaptation, vulnerability and adaptive capacity of agricultural sectors have focused on both developed and developing nations. Studied areas have included rural communities within New Zealand, Canada, Australia, the United States, the Philippines, Vietnam and China (Smit et al., 1996; Kelly & Adger, 2000; Brooks, 2003; Perez, 2003; Bizikova et al., 2014; Wilk et al., 2015; Cradock-Henry, 2017). These studies have considered the changes that have occurred in the climate and the changes made on farms to manage these (Smit et al., 1996) and how stakeholders can improve management and the ability to respond to climate change (Perez, 2003). The studies also considered the social conditions that may exacerbate vulnerability (Kelly & Adger, 2000), and the importance of examining contextual factors when understanding adaptation to climate change (Wilk et al., 2015; Cradock-Henry, 2017). These studies emphasised that vulnerability is not only a function of climate; it is also a function of other determinants that may require attention or response from farmers.

Although many studies have been completed around the world, it is essential to realise that each community faces specific challenges because they are subject to different determinants that affect their exposure, sensitivity, adaptive capacity, vulnerability and adoption of adaptive measures. To improve our understanding of adaptation, vulnerability, and adaptive capacity there is a need for additional studies around the world that focus on communities, areas and conditions that have yet to be researched.

It is accepted that climate change will have implications for all aspects of life and that no place will not be affected by climate change (Stocker et al., 2013). There are differences in the ability of developed countries to adapt to climate change because they have greater access to resources, technology, information and infrastructure that facilitate adaptation processes and reduce vulnerability (Brooks et al., 2005; International Monetary Fund, 2017). Despite this, the adoption and implementation of adaptive measures are not only a function of these tools. The way an issue is perceived also influences adaptation to climate change. Therefore, it is essential that further studies are completed in other rural communities in both developed and developing countries to understand adaptation and the role of perceptions.

2.5. Farmers' perceptions

The adoption of adaptive measures is also affected by perceptions, experience, and knowledge of historical, current and future challenges and opportunities (Burton & Peoples, 2008; Adger et al., 2009). An individual's perceptions of an issue can constrain or motivate action to address a specific risk faced by an agricultural producer (Leiserowitz, 2006; Tarleton & Ramsey, 2008). Perceptions are also related to societal values, and these can inform the development of rules and institutions that govern risk and manage change (Adger et al., 2009). Therefore, there is a relationship between the operating context and perceptions.

Arbuckle et al. (2013) revealed that farmers who had greater concern about climate change had positive attitudes towards adaptive and mitigative management. Mitigative management includes actions that aim to reduce emissions and the severity of climate change, rather than changing behaviours in response to or anticipation of climate change (Arbuckle et al., 2013). Concern and awareness about extreme events were also found to be a motivator for action (Li, Juhasz-Horvath, Harrison, Pinter, & Rounsevell, 2017).

Mertz et al. (2013) found that communities remembered years dominated by extreme events and variability that lead to disturbances in production. Alongside this, they also found that available economic resources could limit the implementation of a measure, even if one perceived a risk (Deressa et al., 2008; Jorgensen & Termansen, 2016). People may also recognise climate change is an issue but may have the inability to implement measures on their own as it may be more suitable to be developed by a public institution (Maddison, 2007). Therefore, understanding context is also imperative in understanding perceptions.

Perceptions differ relative to the importance of an input for a farming system (Niles & Mueller, 2016). Niles and Mueller (2016) noted that sheep and beef farmers did not use as much water as other farmers, and therefore, did not view changes in rainfall as significant when compared to farmers who are more likely to use more water including dairy and viticulture producers. Perceptions can vary relative to the sector (Niles & Mueller, 2016). Niles et al. (2015) compared responses to climate change in Hawke's Bay and Marlborough and found different limiting factors for agricultural producers in each area.

The temperature was the most significant factor in Marlborough and water in Hawke's Bay. This study identified that the dominant industries and climate were different in Hawke's Bay and Marlborough. In Hawke's Bay the dominant farm type was sheep and beef, and in Marlborough it was viticulture. Therefore, the concern about different climatic conditions was related to what was most important for their farming practices.

Perceptions were also found to vary relative to specific characteristics of an agricultural producer including age, gender, marital status, farm type, education, past experiences and social networks and wealth (Bryant et al., 2000; Kelly & Adger, 2000; Jorgensen & Termansen, 2016). For example, educated people are more likely to engage in adaptive behaviours (Deressa et al., 2008). Clark and Tait (2008) found that stakeholders and social networks influence the utilisation of adaptive measures. Past experience of climatic events also impacts perceptions because if people believe they adequately managed previous events, they sometimes think they will be able to do this in the future (Jorgensen & Termansen, 2016).

Understanding perceptions also recognised that adaptive responses occur in response to multiple sources of risk (Niles et al., 2016; Cradock-Henry, 2017). This requires understanding the contextual factors, forces of change and concerns producers have (Niles et al., 2016; Cradock-Henry, 2017). Understanding perceptions on climate change are critical in understanding how people engage with adaptive behaviours and the context that influences decision making. Therefore, there is a need to provide further studies in areas that have not been researched.

2.6. Methods to understand perceptions

Qualitative inquiries and quantitative methods have been used to understand perceptions of climate change (Leiserowitz, 2006; Hyland, Jones, Parkhill, Barnes, & Williams, 2016). This has included studies focusing on specific industries, including the agricultural sector (Maddison, 2007; Deressa et al., 2008; Li et al., 2017). Qualitative studies can identify the different institutional, political, economic and environmental conditions that operate in each place, and the importance of these on decision-making (Adger, 2003; Brooks et al., 2005; Kalaugher et al., 2013). Site-specific studies are essential as vulnerability varies

over time and space, and therefore, different localities are exposed to various sources of risk.

With qualitative methods, it can sometimes be difficult for one to make generalisations from the results (Rivington et al., 2007). Despite this, they provide valuable insights into decision-making, contextual factors and actual adaptive behaviours (Burton & Peoples, 2008; Niles et al., 2015; Niles et al., 2016; Cradock-Henry, 2017). Therefore, they are a valuable tool. Semi-structured interviews have been used to understand perceptions (Smit et al., 1996; van Aalst et al., 2008; Mertz, Mbow, Reenberg, & Diouf, 2009; Cradock-Henry, 2017). This method identifies the importance of engaging with farmers to understand what they perceive as challenges and opportunities, as well as, the adaptive measures they have and could employ, and what affects the decision-making process (Cradock-Henry, 2017). Semi-structured interviews have identified risks posed to producers, what influences the adoption of mitigation and adaptive measures (Niles et al., 2016; Cradock-Henry, 2017).

Surveys are a quantitative method that has been used to understand perceptions relating to climate change (Barnes & Toma, 2012; Jorgensen & Termansen, 2016; Niles & Mueller, 2016). These studies use a Likert scale ranging from strongly agree to strongly disagree, and then the results from these are quantified to identify means and medians of the perceptions (Arbuckle et al., 2015; Niles et al., 2015; Niles et al., 2016). These studies have quantified how concerned people are about climate change, the likelihood of adopting different measures and the contribution of natural and anthropogenic forces of climate change (Arbuckle et al., 2013; Niles et al., 2016). This method masks the diversity of perspectives held by farmers. Another limitation is that people perceive the options differently, and thus it is difficult to understand the consistency between how people view different options (Arbuckle et al., 2013). Alongside this, surveys are limited by the pre-determined choices available, meaning information outside of the questions asked is challenging to uncover.

There is a range of methods that can help to understand farmers' perceptions and the operating context, and the suitability and appropriateness of an approach depend on the purpose of the research.

2.7. Current research in New Zealand

Within New Zealand, there have been studies seeking to understand adaptation, vulnerability, adaptive capacity and perceptions of climate change. Study areas have included Hawke's Bay, Bay of Plenty and Marlborough, and there is currently a limited understanding of other regions in New Zealand (Kenny, 2011; Niles et al., 2015; Niles & Mueller, 2016; Cradock-Henry, 2017). The dominant farm types in the areas examined included orchards, vineyards, sheep and beef, and dairy farms (Cradock-Henry, 2011; Niles et al., 2015; Niles & Mueller, 2016; Cradock-Henry, 2017).

Some of these studies have provided valuable insights into the context operating in these areas and other sources of risk that affect decision-making (Cradock-Henry, 2011; Kenny, 2011; Cradock-Henry, 2017). A few of the studies have focused on understanding how perceptions of climate change affect the adoption of adaptive measures, and some studies found perceptions as being a significant driver for action, and others did not (Niles et al., 2015; Niles et al., 2016). These studies also made clear that the challenges and risks posed to each farming region and sector are variable. However, minimal attention has been given to differentiating between the risks in different industries.

Overall there have been limited studies that have provided an assessment of adaptation, vulnerability, adaptive capacity and the role of perceptions in decision-making. Based on this, there is a need for further studies in New Zealand to improve understanding of how climate change will affect agricultural producers in other areas. Future studies should also examine how there are variations within one region based on different farm types.

One area in New Zealand that has only been researched through computer-based models is Mid-Canterbury, and it provides a valuable study area (Bright et al., 2011). Climate change will pose many challenges to this region, and will likely exacerbate the variability of the climate in this area (Macara, 2016). It is unknown whether the inherent adaptability to climate variability within Mid-Canterbury will make it adaptable to more significant changes in the climate and increases in the magnitude and frequency of extreme weather events. Mid-Canterbury is also heavily reliant on water as an input to farming activities, and the use of irrigation in the region has shaped how the land has been able to be used (Cameron, 2009). Without irrigation, the area would be very susceptible to droughts. Mid-

Canterbury is reliant on agriculture and dairy, sheep and arable farming are three prominent industries within the region; these industries have not been the primary focus of any study in New Zealand (Statistics New Zealand, 2012). It is critical to understand how climate change will affect the area due to its reliance on agriculture. Chapter Three will provide further information about the context in Mid-Canterbury and why this makes it a valuable region for a study as well as the context that affects farmers and their ability to make decisions.

2.8. Conclusion

Agricultural producers will be affected by changes in climatic conditions, and these will pose both opportunities and challenges that will require a response. It is apparent that biophysical assessments and computer-based models that seek to understand the impact of climate change provide a limited assessment on how agricultural producers will be affected. These studies have suggested adaptive options that could be utilised; however, they have assumed adaptation follow a linear trajectory. This fails to recognise the context, risks and perceptions that affect adaptation behaviour.

Adaptation provides options for adjustment for producers to be able to utilise opportunities and minimise risks. Adaptation is related to vulnerability and adaptive capacity. These are both affected by the economic, institutional, political and environmental context, and sources of risk. Therefore, the climate is not the only driver of decision making. These can act to enhance or reduce vulnerability and adaptive capacity. These are both important to consider as vulnerability influences the need for adaptation, and adaptive capacity influences the ability to respond and adjust. Perceptions are also valuable in identifying how people perceive climate change, the associated challenges and risks, and therefore, the actual adoption of different adaptive measures. To understand perceptions and contextual factors that affect vulnerability and adaptive capacity, both quantitative and qualitative methods have been utilised and have included surveys and semi-structured interviews. There are currently limited studies in New Zealand that have done this, and Mid-Canterbury provides a valuable research opportunity.

It is essential that there are case-studies completed that seek to understand vulnerability, adaptive capacity and perceptions in a locality. This helps to understand adaptation

behaviour and provides an in-depth understanding of how climate change may affect agricultural producers. The following chapter will introduce the context operating in Mid-Canterbury that influences vulnerability and can also identify other sources of risk that farmers must respond to, as well as, the justification for the area as a valuable opportunity for a study.

Chapter Three: Understanding the context of Mid-Canterbury

“Water has made Mid-Canterbury”

- Dairy Farmer, Mid-Canterbury

3.0. Introduction

Chapter Two emphasised that vulnerability, exposure-sensitivity and adaptive capacity are affected by the prevailing context, and this has a role in determining the need and ability to adapt to climate change (Cradock-Henry, 2017). There are broad-scale and local-scale determinants that shape vulnerability, adaptive capacity, and exposure-sensitivity, as shown in Figure 3.1. Smit and Wandel (2006) specify that the interaction between physical, environmental and social determinants influence exposure and sensitivity, and the institutional, political and economic context forms the adaptive capacity. As these functions are overlapping, the processes influencing exposure, sensitivity, vulnerability and adaptive capacity are interrelated. These forces are not fixed and vary over and within space, and change over time (Cuevas, 2011).

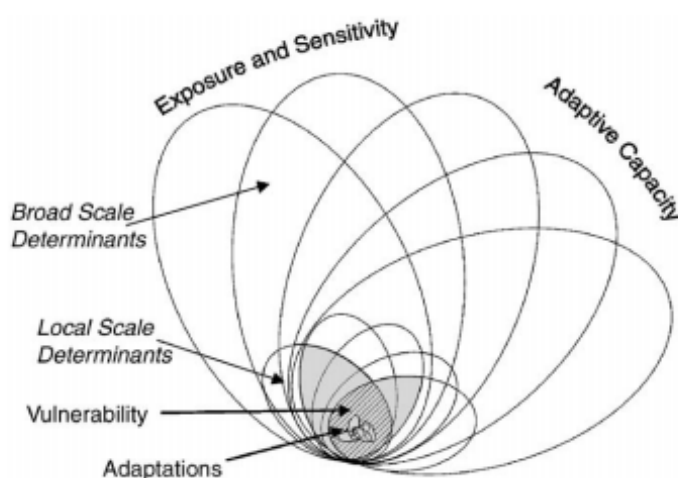


Figure 3.1. Conceptualisation of vulnerability (Smit & Wandel, 2006)

The environmental and physical setting, institutional, political and economic context affects the ability of farmers to implement adaptive measures (Smit & Wandel, 2006). These components also influence what farmers do within their farming practice, and often require attention from an agricultural producer. Therefore, agriculture is a multi-risk and multi-opportunity industry (Bradshaw et al., 2004; Cradock-Henry, 2011). It is essential to understand the context operating as this affects the use of adaptive measures.

This chapter will discuss the context for farming within Mid-Canterbury. It will begin by providing the environmental and physical setting of the area. Subsequently, the economic, political and institutional forces that contribute to the vulnerability of farmers will be examined. Finally, the history of agriculture within the area, the dominant farm systems and the importance of agriculture for the region is discussed. Mid-Canterbury is reliant on agriculture, experiences a variable climate, has widespread use of irrigation and diverse agricultural activities within it, making it a valuable study opportunity.

3.1. Environmental and physical setting

The environmental and physical setting including the soil, topography, climate, and access to water influences vulnerability and exposure-sensitivity (Smit & Wandel, 2006). This section will examine the environmental and physical setting of Mid-Canterbury and discuss climate change as a critical environmental exposure within the area.

3.1.1. Physical setting

Mid-Canterbury covers 6,175km² and extends from the Rakaia River in the north to the Rangitata River in the south (Ashburton Zone Committee, 2011; Ashburton District Council, 2014). The boundaries of the Ashburton District are seen in Figure 3.2. The region includes distinctive areas such as the high-country, foothills and the Canterbury Plains. Intensely folded and fractured greywacke and argillite comprise the foothills and ranges of the catchment (Hudson, 2005). Glacial outwash and fluvial sediment deposits have formed the Canterbury Plains, (Environment Canterbury, 2001).

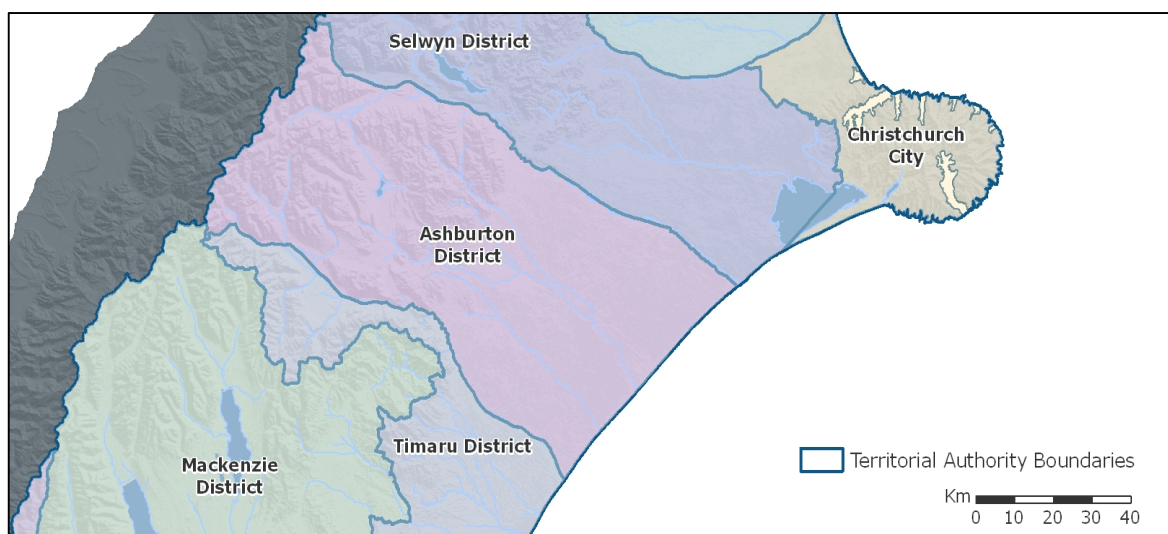


Figure 3.2. The Ashburton District (Environment Canterbury, 2018a)

Within Mid-Canterbury the topography and soil types vary relative to the location (Evans, 2004). Within the high-country, there is a range of topographic features and erosion-prone soils with low fertility (Evans, 2004; Landcare Research, 2018b). On the flat valley areas, there are limited and often stony soils. In the foothills, lowland yellow-brown earth soils are present on the hills. Across the Canterbury plains, there are relatively shallow soils with low water-holding capacity and low natural fertility (Evans, 2004). Lismore Shallow and Lismore Stony Silt Loam are two of the dominant soil types covering the Mid-Canterbury plains. These soils are free draining and are suitable for dairy and arable land-uses when irrigated (NZ Soils, N.d.). Without irrigation, the soil is droughty but appropriate for pastoral farming (NZ Soils, N.d.). The advent of irrigation and fertiliser has enhanced the suitability of the area for agricultural purposes, and the soil type influences an agricultural producer's management and farming practice.

3.1.2. Climate

The climate of Mid-Canterbury provides the agricultural sector with a predictable growing season (Ashburton District Council, 2016). Mid-Canterbury's climate is influenced by the Southern Alps and the prevailing westerly airflows, meaning the area is in the rain-shadow of the mountains and is consequently relatively dry (Macara, 2016). The climate is relatively variable each year. In general, the average annual precipitation is similar each year but when the precipitation is received varies each year as seen in Table 3.1. This can

create issues for agricultural producers depending on the timing of the limited rainfall or heavy rainfall (National Institute of Water and Atmospheric Research, 2017). Farmers have generally been able to manage climate variability. However, it is unknown whether the ability to cope with climate variability will mean farmers can respond to more significant changes and severe events.

Table 3.1. *Annual rainfall and monthly rainfall 2013-2017 in Mid-Canterbury (mm)*

	2013	2014	2015	2016	2017
January	78.6	30.5	18.5	87.6	59.2
February	23.8	58.0	54.3	2.6	13.0
March	44.3	103.0	55.0	44.9	109.2
April	83.1	183.0	127.2	22.2	140.7
May	111.5	56.0	5.7	67.8	44.4
June	220.0	57.2	95.3	57.6	49.7
July	26.3	34.4	28.7	16.6	228.8
August	36.1	27.6	30.7	60.8	108.7
September	47.7	31.1	49.5	28.7	71.2
October	59.8	30.5	18.7	57	-
November	30.1	49.7	12.1	87.2	-
December	83.7	43.7	52.4	46.3	-
Annual	845.0	704.7	548.2	579.3	-

Note. Adapted from: National Institute of Water and Atmospheric Research (2017)

The climate varies across the plains; with harsher conditions in the high-country and more moderate conditions on the plains (Evans, 2004). The distribution of rainfall is not uniform across the plains as seen in Figure 3.3; the amount of precipitation received decreases from the high country to the coast (Macara, 2016). Snowfall events are likely in the high-country. In the past, snowfall events have also created challenges for farmers on the plains. For example, in 2006 between 30 and 60cm of snow accumulated over the plains in Mid-Canterbury, and this created issues for farmers (Evans, 2004; Macara, 2016).

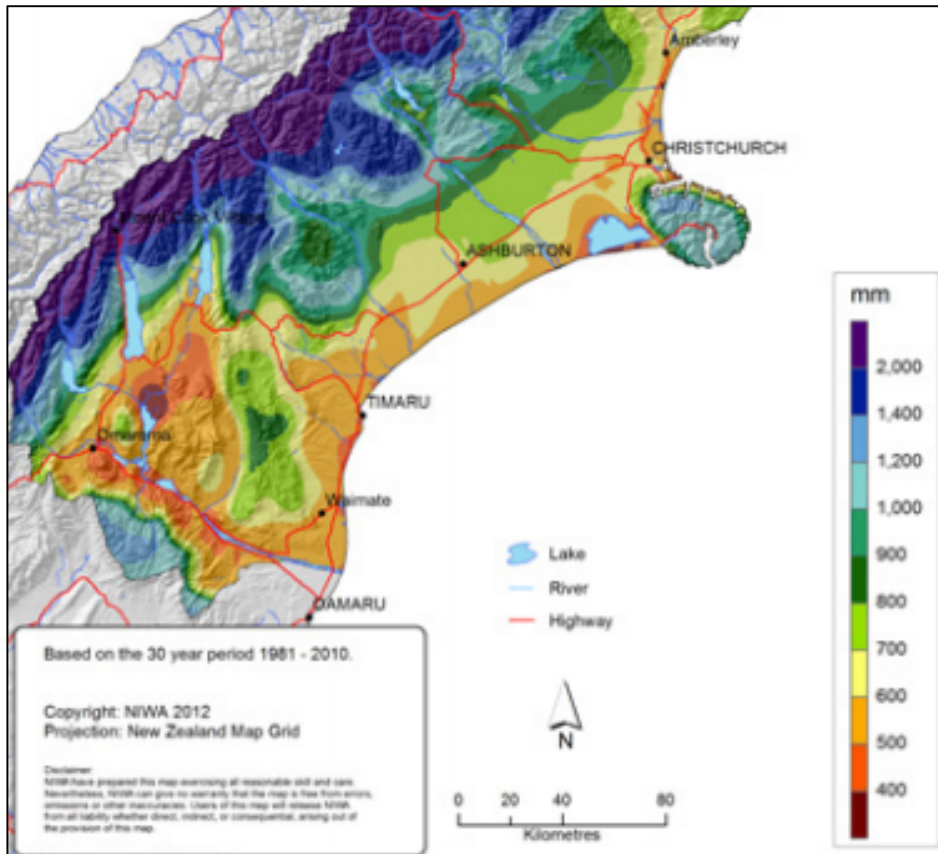


Figure 3.3. Canterbury median annual total rainfall (mm), 1981-2010 (Macara, 2016)

Mid-Canterbury has marked seasonal variations between average summer and winter temperatures. Historically, summers and autumns have been hot and dry, and this provides favourable harvest conditions for arable farmers. This has also made the area prone to droughts (Evans, 2004). In Mid-Canterbury, approximately seven days exceed 30°C per year, and on average 39 days exceed 25°C (Macara, 2016). These hot conditions generate over 40 days of soil moisture deficit in the region, and this can limit pasture and crop growth if there is not adequate water to keep up with the demand (Evans, 2004).

North-westerly winds are another central component of the climate during spring and early summer; these are important for the agricultural sector as they increase evaporation, which affects water demand (Ashburton District Council, 2016; Macara, 2016). Cool easterly winds are also typical; this can add moisture to crops, and affects those located beside the coast during harvest (Evans, 2004). The climate in Mid-Canterbury makes the area suitable for agriculture despite the annual variability.

3.1.3. Climate change

Future climate projections for Mid-Canterbury were estimated by Bright et al. (2011) for 2040. These found that average temperatures would be approximately one degree warmer than the average for 1980-99. Another change was that there could be increases of up to 400mm of rainfall per year in the headwaters but little change in on the plains. There are also potential seasonal changes with the most significant increases in precipitation during winter and spring. Average potential evaporation may increase by 60mm per year on the plains, and this will be most severe during spring and summer (Bright et al., 2011). An increase in average potential evaporation will increase the demand for water and could be problematic if there is not enough water to meet requirements. Other studies have found similar trends within New Zealand (Tait, 2008; Clark et al., 2011; Ministry for the Environment, 2016).

Other changes that may affect Mid-Canterbury include a decline in the number of nights below 0°C which will reduce the number of frosts (Griffiths et al., 2005; Tait, 2008). It is also likely the number of days exceeding 25°C will increase, and the time spent in drought will double or triple by 2040 (Griffiths et al., 2005; Ministry for the Environment, 2008; Clark et al., 2011). It is projected that the magnitude and frequency of extreme rainfall events will worsen and the number of snow days will decline (Sansom & Renwick, 2007; Reisinger et al., 2010; Ministry for the Environment, 2016). Climate change will present both risks and opportunities for agricultural producers; some of the potential impacts are outlined in Table 3.2.

Table 3.2. *Projected change in climate and some of the potential impacts for producers*

Projected change	Potential impact for producers
Increase in average temperature	Heat stress (stock and crops); Reduced productivity and yields; Increased demand for water; Change in varieties grown
Changes in precipitation	Impact will be dependent on whether additional rainfall in headwaters is captured, may increase water demand; Increase in winter could increase pugging
Increase in extreme rainfall events	Increased risks for arable producers depending on the timing of event; Risk of pugging paddock
Reduction in number of frosts	Reduce the removal of bugs and diseases; Problematic for seed germination
Increased time spent in drought	Adverse on crop production and yield

Note. Adapted from: Lee et al. (2012), Lieffering et al. (2012), and Teixeira et al. (2012)

3.1.4. Water

Surface water and groundwater have facilitated the growth of agriculture in Mid-Canterbury through human modifications for stock-water and irrigation (Cameron, 2009). Without this, the area would be very sensitive and prone to droughts. Valuable waterbodies within the area include the Rakaia, Rangitata, Hinds and Ashburton rivers (Evans, 2004). There are significant underground aquifers within the area which are recharged by rivers, rainfall run-off and excess irrigation (Evans, 2004). Many groundwater resources in Mid-Canterbury are over-allocated, as seen in Figure 3.4 (Environment Canterbury, 2018a). This includes the Valetta, Ashburton-Lyndhurst, and Chertsey zones. It is becoming increasingly important to manage and use water more efficiently (Opus International Consultants Ltd, 2012). Bright et al. (2011) suggests that there will be increased precipitation in the headwaters and similar amounts on the plains, but higher evaporation. Additional infrastructure may need to be developed to capture and store the extra rainfall, as without this, theoretically there would be a water deficit on the plains, and this would be adverse for agriculture. This may influence how water is used in the future.

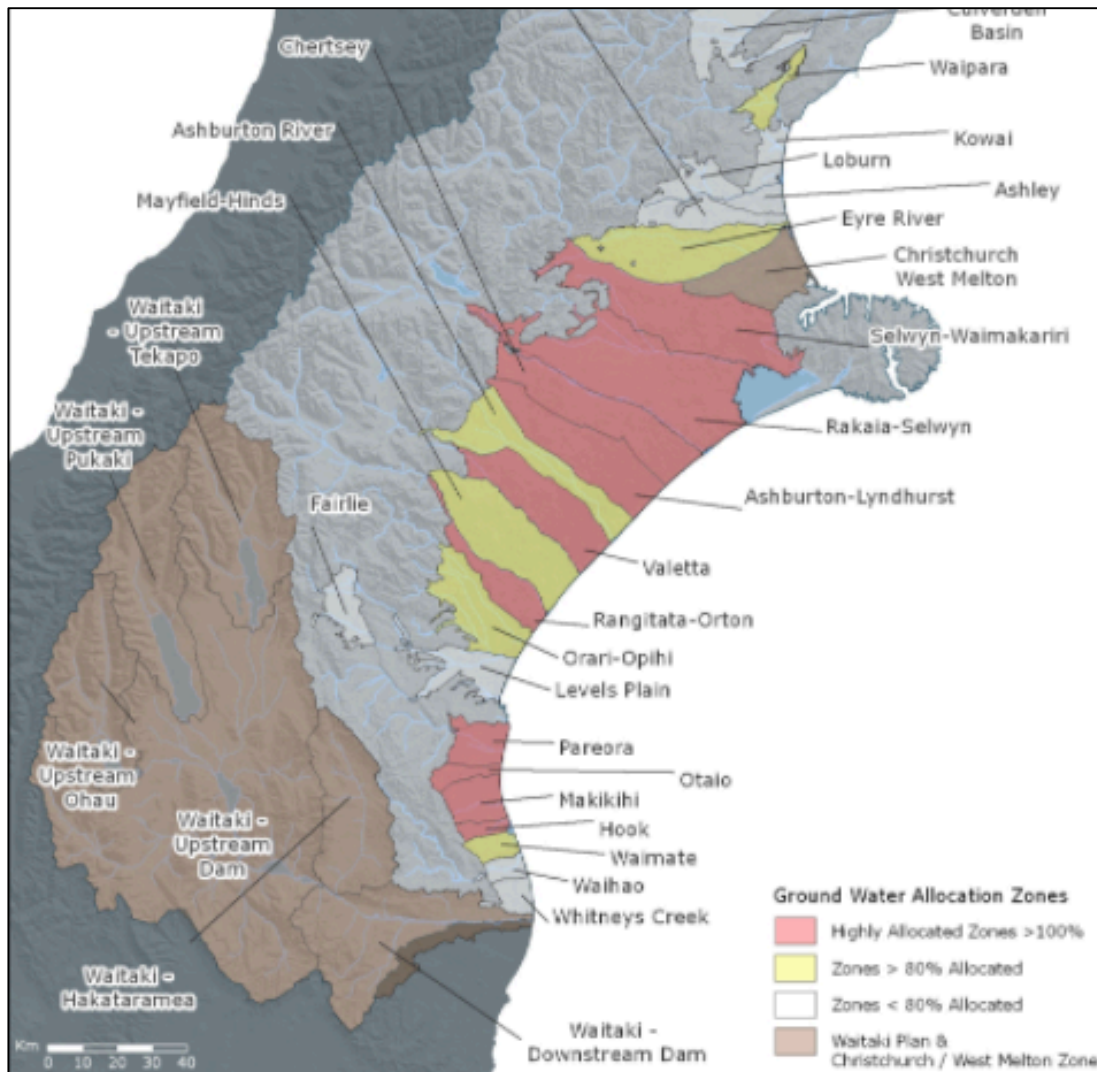


Figure 3.4. Groundwater allocation zones (Environment Canterbury, 2018a)

The provision and availability of water for irrigation is relatively confined to the plains as it is challenging to develop irrigation within the high-country. It is not also not entirely necessary in the high-country because the area receives higher annual rainfall (Macara, 2016). Irrigation schemes in the area include those outlined in Table 3.3. The Rangitata Diversion Race (RDR) was constructed during the 1930s, and this delivers water to five of these irrigation schemes. The other irrigation schemes take their water from drains, groundwater, spring-fed creeks and the Ashburton River (Irrigation New Zealand, 2018).

Table 3.3. *Irrigation schemes in Mid-Canterbury*

	Year created	Area irrigated (hectares)	Sub-scheme of the RDR?
Ashburton-Lyndhurst Irrigation Ltd	1945	25,000	Yes
Mayfield-Hinds Irrigation Ltd	1949	32,000	Yes
Valetta Irrigation Ltd	1958	7,400	Yes
Greenstreet Irrigation	1975	2,347	No
Eiffelton Community Irrigation Scheme	1987	2,622	No
Barrhill-Chertsey Irrigation Scheme	2010 (first stage)	10,000 (2012/2013 season)	Yes and Acton-Irrigation
Acton Farmers Irrigation Cooperative	2011	6,600	Yes and Barrhill-Chertsey

Note. Adapted from: Irrigation New Zealand (2018)

The Managed Aquifer Recharge project in Mid-Canterbury is part of a trial to improve water management in the area (Golder Associates, 2017). The project seeks to replenish declining groundwater, restore flows in coastal drains and restore water quality (Golder Associates, 2017). The study includes the delivery of water from irrigation pipes into an ‘infiltration’ area, and water slowly infiltrates into the groundwater system. The initial findings from this study have shown promising results with an increase in groundwater levels (Golder Associates, 2017). Although this is only a pilot study, it may be a valuable development in the future to secure water.

3.1.5. *Summary*

The physical and environmental setting of Mid-Canterbury has helped it become a prominent agricultural region in New Zealand. Irrigation has been fundamental to mitigate the effects of climate variability. Based on the location on the plains, there are differences in soil type, topography, availability of water and the climate. Therefore, farmers are required to respond to different physical and environmental factors relative to their location on the plains. These factors shape how a system is exposed to harm and thus vulnerability and adaptive capacity (Smit & Pilifosova, 2003; Adger et al., 2005; Engle, 2011).

3.2. Economic forces

Agriculture in New Zealand is reliant on overseas markets and trading, with over 70% of New Zealand's merchandisable exports coming from the primary industry (Ministry for Primary Industries, 2017b). Economic forces and the relationship with the world economy can create challenges and opportunities for agricultural producers, and exacerbate vulnerability (Adger & Brown, 2009). It is essential to understand the economic conditions that have affected agricultural producers in New Zealand.

3.2.1. Economic reforms and de-regulation

Historically, New Zealand has been sensitive to fluctuations in international commodity prices (Buckle, Kim, Kirkham, McLellan, & Sharma, 2007). The economic reforms of the 1980s in New Zealand increased the exposure of the sector to the global financial markets, and this had widespread effects for agricultural producers (Smith & Montgomery, 2004). The reforms removed the subsidies available to agricultural producers. Before the reforms in 1984, 40% of a sheep farmer's income was from agricultural support from the government; thus the removal of this support had significant effects on farmers' incomes (Vitalis, 2009). During this period, the price for agricultural commodities was also declining (Johnson, 2000). As a result, farmers were exposed to increased interest rates, lower income and higher production costs (Vitalis, 2009). Many farmers had to sell land, diversify their income sources and reduce farm expenditure to survive during this period (Pomeroy, 2015).

The diversification of the agricultural sector marked the start of a notable rise in the area used for dairy farms in the South Island. The reforms also had far-reaching environmental impacts from diversification and intensification including degrading water quality, loss of biodiversity and soil degradation (Haggerty, Campbell, & Morris, 2009). The past economic context has shaped the sensitivity of New Zealand's agricultural sector to the international markets (Buckle et al., 2007).

3.2.2. Current economic context

As New Zealand's agriculture industries are export orientated, it is important to note that different industries have different exposures to the global commodity and financial markets (Buckle et al., 2007; Teixeira et al., 2012; The Treasury, 2016). For example, Fonterra, a dairy company, has a critical role in the regulation of the dairy industry and can minimise the risks posed by the market to producers by smoothing some of the price fluctuations (Gray & Le Heron, 2010). In comparison, sheep farmers sell directly to processors and processors market and distribute products. Furthermore, arable farmers produce a lot of products for domestic consumption; despite this, they are still increasingly sensitive to global prices as these determine the price produce and grain is sold within New Zealand (Teixeira et al., 2012).

Around the world, shifts in consumer behaviours are influencing the demand for different products. There is an increasing demand for alternatives to animal-based products. Consumer demands also affect the way products are manufactured and processed. People are increasingly seeking good quality products that have been produced with environmental considerations (Anderson, 2010). The projected increase in human population is expected to sustain and increase the demand for agricultural products (Rojas-Downing, Nejadhashemi, Harrington, & Woznicki, 2017). This will be important for agricultural producers in New Zealand, and the commodity and financial markets will continue to affect the vulnerability of producers. The current economic context will be further elaborated on in Section 3.4 when the importance of dairy, arable and sheep farming in Mid-Canterbury is discussed.

3.2.3. Summary

The past economic context has shaped the agricultural system and the exposure to global financial and commodity markets (Hardaker et al., 2004). Agriculture in New Zealand is reliant on exports and is susceptible to price fluctuations and instabilities which may be a result of global crises, climatic conditions in other parts of the world, or changing consumer demands. The vulnerability of agricultural producers is affected by exposure to the global financial and commodity markets.

3.3. Political and institutional forces

The political and institutional context that farmers operate within affects adaptive capacity and vulnerability (Smit & Wandel, 2006). Central and local authorities, legislation and regulations govern the use of natural and physical resources, and what agricultural producers can do. Industry groups and organisations also influence what agricultural producers can do. Any changes in the political or institutional environment can affect producers but are mostly outside of their control (Hardaker et al., 2004).

3.3.1. *The Resource Management Act*

The Resource Management Act (1991) provides the foundations for the sustainable management of natural and physical resources within New Zealand and has a hierarchical approach to management as seen in Figure 3.5. This approach designates different responsibilities to different authorities (Ministry for the Environment, 2015).



Figure 3.5. The approach to resource management in New Zealand (Ministry for the Environment, 2015)

3.3.2. Central government

The central government develops policies, standards and legislation to manage resources. To do this, they have agencies with different responsibilities. Two principal agencies include the Ministry for Primary Industries who regulate trade, exports, biosecurity and food safety, and the Ministry for the Environment who advise and regulate the management of the natural and physical environment including the water, air and soil.

The election of 2017 illustrated the importance of the central government and how it can affect agricultural producers. The Labour Party campaigned on a ‘water tax’ policy. This would include irrigation users, and “the royalty for irrigation water is expected to be around 1-2c per 100 litres” (Labour, 2017). Many farmers identified how this would affect their livelihoods and a range of results suggested it could cost affected farmers between \$13,000 and \$50,000 per year (Radio New Zealand, 2017). Following the election, the new government announced that the Ministry for Primary Industries would act as an overarching body for portfolios including agriculture, food safety, biosecurity, rural communities, forestry and fisheries (Ministry for Primary Industries, 2018). This restructuring is expected to occur in April 2018 and there is currently limited information about the implications of this. The aim is to have greater accountability and engagement with stakeholders.

3.3.3. Regional and territorial authority

Environment Canterbury is the governing regional authority for Mid-Canterbury, and the Ashburton District Council is the territorial authority. Environment Canterbury is responsible for the sustainable use of resources including water use and take, and activities that occur on land including farming (Environment Canterbury, 2015). Therefore, the regional council can influence what farmers do (Environment Canterbury, 2015).

The Canterbury Water Management Strategy (CWMS) was developed by Environment Canterbury in 2009 as result of a significant increase in the demand for water, and issues of water quality. There was a need to improve the way water resources were managed (Jenkins, Russel, Sadler, & Ward, 2014). The CWMS seek to provide a collaborative decision-making framework in which multiple stakeholders and communities are engaged.

It involves setting environmental limits for river flow and water quality, controlling the use, take, diversion and damming of water to ensure the sustainable use of water (Environment Canterbury, 2015). This has begun to create limits for irrigation and will affect farmers and restrict the further intensification of land-uses (Environment Canterbury, 2015).

Environment Canterbury regulates Farm Environment Plans, and these seek to help farmers achieve good management practices by identifying and managing on-farm environment risks and by reducing nitrogen losses. Farm Environment Plans also aim to improve the use of irrigation, water, effluent, land, soils, waterways and waste management (Environment Canterbury, 2016b). These plans identify whether a resource consent to farm is necessary based on the nitrogen loss calculation and nutrient limits within the designated zones (Environment Canterbury, 2016a).

There are three zones in Mid-Canterbury for nutrient limits: the Hinds/Hekeao Plains Area, the orange zone and the red zone, as seen in Figure 3.6. A resource consent to farm is required if the farm is not covered by the Barrhill-Chertsey Irrigation or Rangitata Diversion Race consent, and the other requirements are seen in Table 3.4.

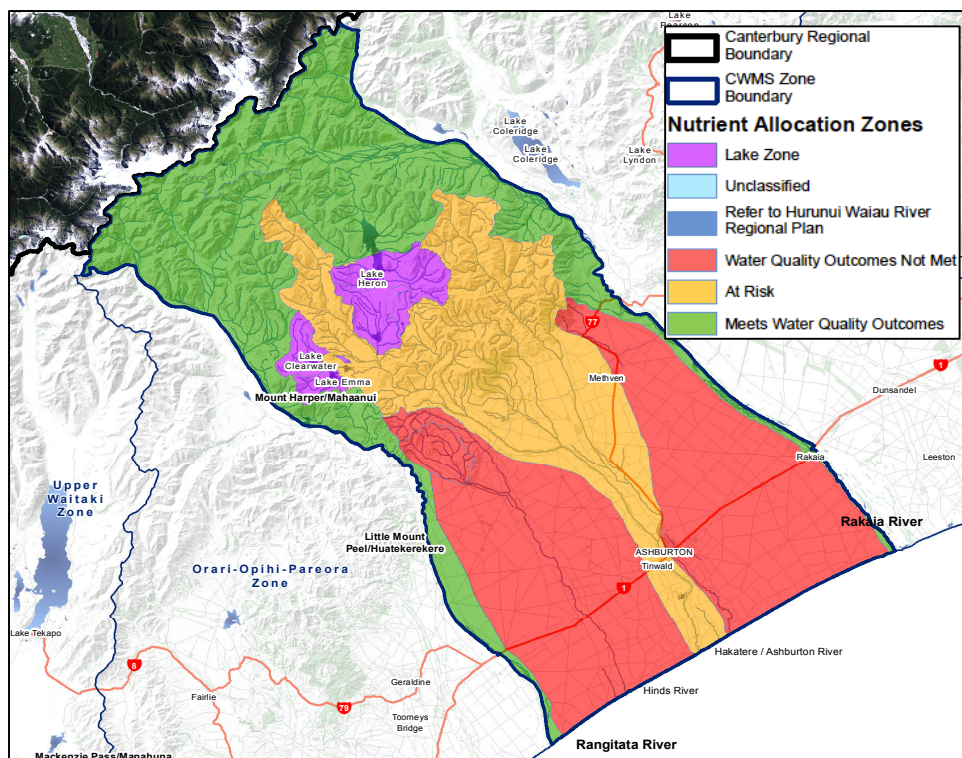


Figure 3.6. Image showing the nutrient zones within Mid-Canterbury (DairyNZ, 2018)

Table 3.4. *The requirement for resource consents to farm within Mid-Canterbury*

Area	Requirement for resource consent:
The Hinds/Hekeao Plains Area	Larger than 5 hectares and the nitrogen loss calculation exceeds 15kg per hectare per year
Orange Zone	Farm's nitrogen loss exceeds 20kg per hectare per year and: <ul style="list-style-type: none"> • Property is larger than 50 hectares; OR • The nitrogen loss calculation has increased above your nitrogen baseline
Red Zone	Property is over 5 hectares and nitrogen loss calculation exceeds 20kg per hectare per year. An increase above baseline is prohibited

Note. Adapted from: Environment Canterbury (2016a)

3.3.4. Industry groups and organisations

There are many industry groups that farmers work alongside. The Foundation of Arable Research, Beef and Lamb, DairyNZ and Irrigation NZ are some of the dominant groups that farmers interact with in Mid-Canterbury. These organisations have helped to define what constitutes good management practices and have Environment Canterbury approved Farm Environment Plans; therefore, they help farmers comply with the regulations and rules set by the regional council (Environment Canterbury, 2018b). These groups also provide submissions on resource consents that may affect farmers to ensure their voice is represented. Industry organisations also host field days which farmers are invited to attend, and these can demonstrate how to improve their farming practice and new technological innovations. Therefore, they can influence farmer's behaviour.

Research institutions and Crown Research Institutes (CRIs) are also important. These are independent agencies, but are accountable to the New Zealand Government and monitor and analyse challenges faced by agricultural industries. AgResearch develops technology and science projects for the benefit of the agricultural sector and this includes projects on agricultural greenhouse gas mitigation (AgResearch, 2018). The National Institute of Water and Atmospheric Research provides insights into climate change adaptation and mitigation (National Institute of Water and Atmospheric Research, 2018). Landcare seeks to enhance the ability of industries to operate within environmental limits while meeting market demands. They also facilitate the sustainable use of land resources in New Zealand

(Landcare Research, 2018a). These agencies are valuable as they can provide the central and local authorities with research and information that can shape policy and regulations.

Federated Farmers is New Zealand's leading rural advocacy organisation. They operate at provincial and national levels, and represent rural interests in policy development, presenting industry positions and provide supporting documentation on many issues. This can ensure farmers voices are represented in decision-making processes that would affect farmers. Federated farmers also seek to add value to farming in New Zealand and encourage sustainability; therefore, can influence the behaviour of a farmer and their farming practice (Federated Farmers of New Zealand, 2018).

3.3.5. Summary

The central and local government have a role in determining what agricultural producers can do. Industry group and organisations can support and encourage farmers to change their farming practise and behaviour relative to a challenge or opportunity. However, dependent on the rule and regulation they can also limit the ability of farmers to adjust their farming practice, and therefore, can alter the exposure of a farmer to a risk or harm. The central and local governments and industry organisations all affect adaptation.

3.4. Agriculture within Mid-Canterbury

Agricultural producers are affected by the physical, economic, institutional and political forces described in this chapter. This section will examine the history of the area and how the history and how the previously discussed context has transformed and shaped agriculture within Mid-Canterbury (Evans, 2004; Cameron, 2009). It will then explain why the three agricultural sectors chosen for this research are significant and provide further information about the current economic context.

3.4.1. History

Settlers began to arrive in Ashburton in the 1850s, and in 1858 the area now known as the Ashburton town was established (Scotter, 1972; Evans, 2004). During this period, sheep and beef run-holders occupied most of the land. Cropping became a dominant land-use in

the late 1860's. The exact portion of the area used for each farming activity varied relative to the rising and falling prices of crops, wool and meat (Scotter, 1972; Cameron, 2009). The opening of the Canterbury flour mill, the expansion of the railway system from Christchurch to Ashburton, the development of refrigeration and the opening of the freezing works in Ashburton in 1899 also influenced land-use changes (Scotter, 1972; Evans, 2004). These advancements changed the way agricultural goods were produced, processed and exported.

In the early days, it was recognised that farming the area would be limited if water was not accessible. During the 1860s the stock-water system was developed, and this sought to deliver stock with drinking water around the region. The water race continues to function to a degree today; however, it is generally redundant with the changes in land-use and the increased use of groundwater to supply stock drinking water (Scotter, 1972).

Irrigation has been critical for agriculture growth in the area (Cameron, 2009). Irrigation was discussed by the council in the 1880s, and during this period, there was the experimentation of small-scale irrigation schemes by the council and innovative farmers. In the 1930s the Rangitata Diversion Race (RDR) was constructed through the Public Works Scheme. The RDR is now used for irrigation and power generation. It provides water for irrigation in five areas including the Ashburton/Lyndhurst, Mayfield/Hinds, Valetta, Barrhill and Rakaia zone (Cameron, 2009).

The first irrigation system in the region was the Ashburton/Lyndhurst border dyke system that opened in 1944 and allowed water to be flooded over 26,000 hectares of land in a controlled manner (Evans, 2004). This system was financially viable but was very wasteful of water. Since the 1970s and the 1980s, there have been advancements in irrigation technologies to improve the efficiency of water use. Increasingly, centre pivots and laterals are used throughout the region, and this improves water use efficiencies. Irrigation along the coast and river began to be sourced from shallow groundwater in the 1960s and 1970s (Cameron, 2009).

Irrigation is very costly and has influenced land use patterns in the region. Notably, from the 1990's dairy farms began to occupy large portions of the plains because they were

economically justifiable on irrigated land in comparison to sheep farming (Cameron, 2009). During this period, the world demand and commodity prices for dairy products were rising. This provided a greater return than was available in the sheep industry and motivated shifts in production regimes (Harrington, 2005; The Treasury, 2005). Arable land-uses continue to occupy the plains and have benefited from the development of irrigation. Sheep farming is now predominantly confined to the high-country that is not irrigated. In Mid-Canterbury dairy, arable and sheep farming practices continue to be of importance.

3.4.2. Agricultural industries in Mid-Canterbury

Dairy

The dairy industry accounts for 45% of New Zealand's agricultural export sales (The Treasury, 2016). Dairy farming occupies much of the Mid-Canterbury plains, and it is one of the most productive dairy regions in New Zealand (Cameron, 2009; DairyNZ, 2017b). In the 2016/17 season, there were 410 dairy herds and 339,000 cows; this was a notable increase from 2000 when there were only 76,000 cows in 141 herds (Infometrics, 2016; DairyNZ, 2017b). Producers are reliant on rainfall and irrigation to support grass-based systems of production. Therefore, these systems are sensitive to changes water availability (Lee et al., 2012). The pasture-based system provides New Zealand with a competitive advantage for having relatively low operational costs. However, increasingly there has been the intensification of dairying in New Zealand with increases in the amount of feed imported and waste generated. This increases productivity, however, it also increases operating costs and has begun to erode New Zealand's competitive advantage (Mounsey, 2015).

The industry is reliant on exporting products and produced 855% more milk than the domestic market could consume (International Farm Comparison Network, 2014, in Mounsey, 2015). The industry is sensitive to changes in global demand and financial instabilities (Lee et al., 2012). For example, in the 2013/14 season, the average payout rose to approximately \$8.47 per kilogram of milk solid due to strong demand from China. This eventually declined to \$4.69 for the 2014/15 season, and rose again in the 2016/17 season to \$6.47, showing the variability of the industry (The Treasury, 2016; DairyNZ, 2017b).

Two main exporters and processors that Mid-Canterbury farmers supply are Fonterra and Synlait and these companies have different approaches (TDB Advisory Ltd, 2017). Fonterra is a dairy co-operative owned by 10,000 farmer shareholders in New Zealand and it is the dominant exporter, totalling approximately 84% of market share of the dairy industry (Fonterra, 2017; TDB Advisory Ltd, 2017). Fonterra is the leading exporter of dairy products including milk powder, milk, butter and yoghurt to 100 countries around the world (Fonterra, 2017). Fonterra has factories throughout New Zealand with major processing plants near Mid-Canterbury including at Darfield, and Clandeboye, as seen in Figure 3.7.

In contrast, Synlait is a Canterbury-based producer and is also heavily reliant on exports but targets a different market including high-value milk products, infant formula and cream. Synlait and Fonterra pay similar prices. However, Synlait pays higher for A2, and grass-fed milk from farmers with Synlait accredited 'superior farming' practises which require farmers to follow specific management strategies and behaviours (TDB Advisory Ltd, 2017). Both Fonterra and Synlait have begun to encourage more environmentally appropriate behaviours as they identify that this is what the market demands (Synlait, 2013b; Fonterra, 2017). However, Synlait has founded their business approach on sustainability, while Fonterra has been encouraged to shift behaviours due to consumer demands and increased competition from other producers. The Synlait factory is located between Ashburton and Christchurch, as seen in Figure 3.7.

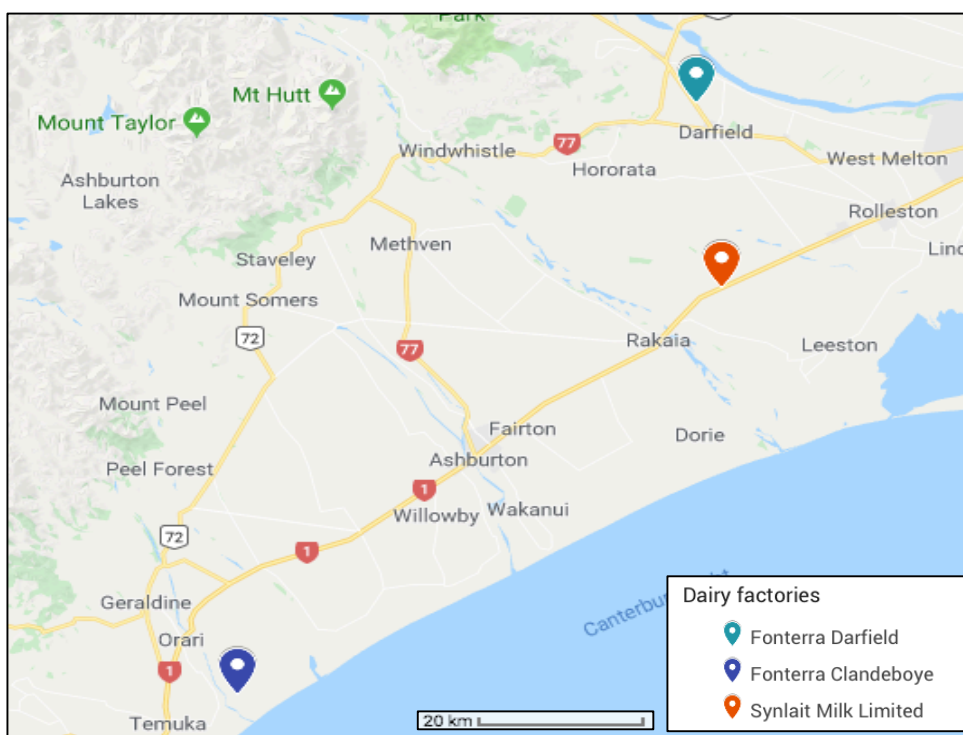


Figure 3.7. Location of dairy factories near Mid-Canterbury (Google, 2018)

Arable

New Zealand has a highly productive arable sector in comparison to the rest of the world due to New Zealand's favourable climate, high technological literacy and use of optimal management strategies (Teixeira et al., 2012). The arable industry, including fruit, vegetable, other horticulture, crops and seeds accounted for 20% of New Zealand's agricultural sales (The Treasury, 2016). In 2012 there was approximately 294 arable farms operating across the Mid-Canterbury plains where irrigation is available, and dry summers prevail (Statistics New Zealand, 2012). The area specialises in the production of high-value crops, vegetable seeds, barley and wheat (Cameron, 2009; Statistics New Zealand, 2012). In total 46.6% of wheat, 29.4% of barley and 55.2% of New Zealand's vegetable seeds are produced within the area (Statistics New Zealand, 2012). This production base is supported by the abundant seed companies including PGG Wrightson, Canterbury Seeds and Midland Seeds within the area. It is essential arable farmers develop relationships with these organisations as they supply the seeds to producers.

The arable sector is sensitive to changes in temperature, precipitation and extreme weather events; these can have adverse effects on crop yields and can destroy crops (Teixeira et al., 2012). The industry is affected by overseas climatic conditions as any change in yield overseas can increase or decrease the demand for crops from New Zealand. The arable

sector within Mid-Canterbury also grows fodder crops and grain that the dairy sector can use for winter grazing. This provides an option for arable farmers to diversify their production. However, the price of grain overseas is currently low due to oversupply and this puts a cap on the price that New Zealand farmers can ask for (Ministry for Primary Industries, 2017a). In comparison to the dairy industry, the arable industry is not as reliant on overseas exports, and approximately 60% of arable production is consumed domestically (Teixeira et al., 2012). However, it is still sensitive to the global commodity and financial markets.

Sheep

Sheep farming has historically been a significant part of farming in Mid-Canterbury. The total number of sheep in Canterbury has steadily declined with approximately 9,700,000 sheep in 1994 to 4,500,000 in 2015 (Statistics New Zealand, 2017b). This occurred throughout New Zealand, and the pronounced increase in dairy cattle correlates with this period. In Mid-Canterbury now, there are only 210 specialist sheep farms, and many sheep farmers also have beef stock on their properties (Statistics New Zealand, 2012). The main activities include selling of store lambs, fattening of stock and selling wool (Evans, 2004).

New Zealand sheep production is highly productive with increased lambing percentages and the average weight of stock since the 1980's (Morris, 2009; Beef and Lamb New Zealand, 2017). Currently, sheep meat and wool account for 13.3% of agricultural products exported in New Zealand (The Treasury, 2016). The reduction in numbers is also visible in the closure of Silver Fern Farms in Mid-Canterbury. This is only partially related to the decline in numbers it is also associated with the financial profile of Silver Fern Farms.

Sheep farms within the area are predominantly in the high-country (Cameron, 2009). Sheep farming in New Zealand is characterised as low-cost to be able to compete on export markets, and therefore, have sizeable flocks, low labour and efficient utilisation of pastures (Morris, 2009). Within the high-country in Ashburton, there is generally enough rainfall to ensure there is adequate pasture-growth without the application of water to the land (Macara, 2016). However, the sector is still sensitive to variations in rainfall and producers are sometimes required to import feed. Sheep farmers are often exposed to harsh conditions and snowfall which can have adverse effects on stock (Lieffering et al., 2012).

The sheep industry is sensitive to the global market and instabilities. The sector benefited from trade with China in 2013/14, and in 2014/15 this declined due to less demand and increased competition from other markets such as Australia, where slaughter rates were high due to drought conditions (The Treasury, 2016). This illustrates the vulnerability of sheep farming within New Zealand to the global context.

3.4.3. Importance

Agriculture is critical for the Mid-Canterbury district. The agriculture, forestry and fishing sector underpins the economy of Mid-Canterbury. Dairy farming, sheep, beef cattle and grain farming account for 23.4% of the regions GDP; highlighting the importance of a few industries in the region (Infometrics, 2016). Between 2015 and 2016 the annual growth rate in the agriculture, forestry and fishing sector was 4.3% and this indicates that the dominance of agriculture is unlikely to slow down anytime soon. Manufacturing, the processing of meat and seeds and other agricultural services and trades are also a critical part of Ashburton's economy (Infometrics, 2016).

Agriculture provides valuable employment opportunities in the region with a total of 25.5% of the population employed in the agriculture, forestry and fisheries industry (Infometrics, 2016). Between 2006 and 2016, there were a total of 1,033 new jobs created in this sector (Infometrics, 2016). The growth and development of the different agricultural industries in Mid-Canterbury have facilitated the population and economic growth of the Ashburton District over the last ten years.

3.4.4. Summary

The use of water for stock water and irrigation within Ashburton has shaped how the land has been used by agricultural industries. The dairy, arable and sheep sectors within the area are all significant sectors, and the discussion above has highlighted how they are distributed in different places within Mid-Canterbury and have different climatic sensitivities based on their location within the area. The three industries are all susceptible to the global financial and commodity markets in different ways. Agriculture is fundamental for the economic and employment opportunities it provides to those directly

employed in the agricultural sector as well as secondary and tertiary industries supporting agriculture. Mid-Canterbury is a valuable study area as it is an area with a range of agricultural industries, and no current studies seeking to understand vulnerability and adaptation have compared different farm systems within one area. It is also valuable due to its dependence on natural resources, notably water. Finally, it is an area that has a variable climate, and it is unknown whether this variability will enable farmers to adapt to more extreme weather events as anticipated with climate change.

3.5. Conclusion

To understand adaptation to climate change of agricultural producers within Mid-Canterbury, it is necessary to understand the broader context affecting producers, and this includes both local and broad-scale determinants. These factors shape vulnerability, exposure-sensitivity and adaptive capacity, and can also identify other sources of risks that farmers may have to respond to (Adger & Brown, 2009). This chapter has illustrated the physical and environmental, economic, institutional and political forces that affect farmers within the area.

The physical and environmental setting has shaped the use of the land for agricultural purposes. Farmers are reliant on global commodity and financial markets and became increasingly vulnerable to the global financial market following the reforms of the 1980s. Consumer behaviour and wants are now influencing the demand for goods produced with appropriate environmental measures in place. Farmers operate within a complex political and institutional environment that is shaped by the central government, local government and different organisations. These forces shape the vulnerability, adaptive capacity and exposure-sensitivity of agriculture within the region.

Mid-Canterbury provides a valuable case-study opportunity as it is a region prone to a variable climate, shaped by water, has a range of agricultural industries operating and an area reliant on agriculture. Due to the dependence on climate in the area, it is essential to understand how farmers within the area have and could adapt and respond to opportunities and challenges that will be posed by climate change. The following chapter will discuss the methodological approach utilised for this research.

Chapter Four: Methodology

“...when you start talking to people who are involved, you see it [the climate] from a different perspective”

- Arable farmer, Mid-Canterbury

4.0 Introduction

This thesis employs a case-study qualitative approach to investigate how climate change will affect dairy, arable and sheep farming practices in Mid-Canterbury. The strategy of inquiry can be split into three phases: (1) the development of the research approach and situating the research within the current body of literature that exists on adaptation, adaptive capacity, vulnerability and perceptions of climate change; (2) data collection using semi-structured interviews. This method identifies perceptions of climate change, climatic challenges and opportunities, adaptive strategies and contextual factors affecting agricultural producers in Mid-Canterbury; (3) analysis of the data gathered from the semi-structured interviews to understand how climate change will affect dairy, arable and sheep farming practises in Mid-Canterbury. The completion of these components helps to achieve the research objectives. The strategy of inquiry will be discussed in this chapter.

4.1. Research approach

Adaptation provides opportunities for agricultural producers to adjust to climate change. As identified in Chapter Two, the use of adaptive measures is affected by vulnerability and adaptive capacity, and this relates to the perceived need and ability to respond to climate change and the effects (Smit & Wandel, 2006; Adger et al., 2009). The need and ability to adapt to climate change varies relative to perceptions of climate change, opportunities and challenges, and the physical and environmental setting (Kelly & Adger, 2000; Deressa et al., 2008; Jorgensen & Termansen, 2016). Therefore, to understand this variation it is necessary to use a method that can capture how climate change will affect agricultural producers in a locality at a point in time.

In New Zealand, studies seeking to understand farmers' perceptions of climate change, adaptive capacity and vulnerability have been completed in the Bay of Plenty (Cradock-Henry, 2017); Marlborough and Hawke's Bay (Niles et al., 2015; Niles & Mueller, 2016);

and eastern regions (Kenny, 2011). These studies have used surveys or semi-structured interviews. Surveys have been beneficial to collect standardised information about participants. However, the questions they ask are pre-determined and ask respondents to express their concern using a Likert scale. The use of a Likert scale is limiting as it does not allow additional information outside of the answer schedule to be collected. It also does not let farmers illustrate what they perceive as likely effects and assumes the researcher and questionnaire cover the primary sources of risk. The studies utilising semi-structured interviews have been able to provide more in-depth information about how climate change will impact agricultural producers, and help to identify the contextual factors that affect agricultural producers when responding to climate change. They also allow farmers to highlight what they perceive as challenges and opportunities.

These studies examined agricultural producers from kiwifruit orchards, vineyards, sheep and beef, and dairy farms, and compared the challenges, opportunities and perceptions of agricultural producers from different regions (Cradock-Henry, 2011; Niles et al., 2015; Niles & Mueller, 2016; Cradock-Henry, 2017). Although these studies noted the farm type of respondents, there were minimal comparisons between each farm system. This provides a limited assessment of how climate change will affect agricultural producers within a region by not recognising the different challenges and opportunities posed to each sector, and therefore, their different adaptive capacity and responses.

There have been no current attempts to explore vulnerability, adaptive capacity and perceptions of climate change in Mid-Canterbury. As highlighted in Chapter Three, Mid-Canterbury is reliant on agriculture, and climate change is expected to pose both opportunities and challenges. Therefore, it is critical to understand how agricultural producers perceive climate change and the ways in which they can respond (Ashburton Zone Committee, 2011). This is valuable because perceptions influence the need to respond to a change. This study also aims to illustrate the similarities and differences different each farm system. Therefore, it is essential a methodology is developed that captures this. Qualitative research methods provide an opportunity to explore this topic.

4.2. Qualitative research

Qualitative investigations utilise assumptions and theoretical frameworks and allow researchers to understand, interpret and find patterns in the words that individuals use to explain human environments and experiences (Winchester & Rofo, 2016; Cresswell & Poth, 2017). As people express themselves through words, qualitative research provides a way to understand and capture people's experiences, opinions and values (Winchester & Rofo, 2016). Thus, they yield insights into the social world and values of the participants that quantitative methods do not capture (Ormston, Spencer, Barnard, & Snape, 2014). This is valuable because perceptions influence behaviours.

Creswell and Poth (2017) identified five qualitative approaches to inquiry including narrative research, phenomenology, grounded theory, ethnography and case studies as illustrated in Table 4.1.

Table 4.1. *Description of the five qualitative approaches to inquiry*

	Research focus	Research problem
Narrative research	Explores the life of an individual	Tell stories of individual experiences
Phenomenological research	Understands the essence of the experience	Describe the essence of a lived phenomenon
Grounded theory research	Develop a theory grounded in data from the field	Ground a theory in the views of participants
Ethnographic research	Describe and interpret a culture-sharing group	Describe and interpret the shared patterns of culture of a group
Case study research	Develop an in-depth description and analysis of a case or multiple cases	Provide an in-depth understanding of a case or cases

Note. Adapted from: Cresswell and Poth (2017)

The purpose of this research is to examine how agricultural producers within an area will be affected by climate change. Case study research can provide a comprehensive understanding of a case or cases and therefore, is the most suitable qualitative approach for this study (Cresswell & Poth, 2017). A case is described within specific parameters at a point in time (Baxter, 2016; Cresswell & Poth, 2017). For this research, the 'case' is considered in three ways. The case refers to each farm, the collection of farms within each farm system and the area that is territorially defined as Mid-Canterbury. Therefore, each farm represents a small case, within a larger-case (the farm system group), and within a

larger-case again (the region). Case study research also acknowledges that the context the research is undertaken within is likely to have some effect on the case, and on the nature of the data collected (Yin, 2014). The bounded parameters of the 'case' also allow the variation in context across space and time to be captured. A case study methodology provides an opportunity to explore vulnerability, adaptive capacity and perceptions of climate change within an area, and how this varies within an area that has not been studied in these respects.

Case study research encourages the integration and collection of data that provides an in-depth understanding of the case and cases and may include interviews, observations, documents and audio-visual recordings (Cresswell & Poth, 2017). Interviews are verbal interchanges and dialogues that can provide a detailed understating of a topic (Valentine, 2005; Dunn, 2016). The nature of these varies along a continuum relative to their structure (Dunn, 2016). At one end, structured interviews operate and contain carefully worded and ordered questions; in contrast, unstructured interviews develop entirely based on the ideas and experiences expressed during an interview (Dunn, 2016). Situated between these two interview types are semi-structured interviews, where the order and questions are somewhat pre-determined but are flexible and can be altered by the comments and interests expressed during the interview (Dunn, 2016).

Semi-structured interviews were considered the most appropriate method for my research due to their flexibility (Kitchin & Tate, 2000). The structure allowed me to develop an interview script but also allowed me to capture points of interest that could not be investigated by a structured interview. As farmers from three different farm types were interviewed, it could not be assumed that all questions would be relevant to each farm type (Silverman, 1985, 2010). Semi-structured interviews take a conversational form and can adjust relative to the opinions expressed by the respondent and therefore capture additional information that would be inaccessible in a scripted interview (Kitchin & Tate, 2000; Valentine, 2005). Semi-structured interviews can collect a range of opinions and this helps to understand the case and cases in this research (Silverman, 1985; Dunn, 2016).

4.2.1. Consultation

In developing the methodological framework, Lynda Murchison from Federated Farmers and Nick Cradock-Henry from Landcare Research were consulted during March and April 2017. Both these individuals have completed research using qualitative methods with farmers. Lynda utilised a narrative methodology in her study. She recommended the use of a coding system for interview respondents to ensure their anonymity. Lynda is also the North Canterbury Provincial President of Federated Farmers and provided information about Federated Farmers' stance on climate change (L. Murchison, personal communication, 31 March 2017). This was important to be aware of before the commencement of fieldwork, as farmers from Ashburton could have a similar position if they had relationships with Federated Farmers.

Nick Cradock-Henry is a social researcher at Landcare Research and has utilised semi-structured interviews in his work. He also highlighted that farmers respond to multiple opportunities and challenges (Cradock-Henry, 2011, 2017). This helped to emphasise the importance of understanding context alongside understanding how climate change will affect agricultural producers. He identified other sources of information that I may find useful through looking at my reading list and emphasised the importance of conducting interviews with farmers at quieter times of their season (N. Cradock-Henry, personal communication, 4 April 2017). It was helpful to hear about other people's research experience prior to the commencement of fieldwork because it highlighted issues I had previously not considered. It was also beneficial because both had positive experiences and outcomes of using qualitative inquiries, and this helped to affirm that it was an appropriate method for my research.

4.2.2. Health and safety and human ethics

Prior to beginning data collection, health and safety forms were completed and approved. These identified the likely risks that would be encountered when travelling to and from an interview location or at the interview location. It also provided ways to minimise the risk, and responses if the risk is still encountered following minimisation.

As my research involved the questioning of people, human ethics was completed before the fieldwork commenced. During the completion of this, I was required to think about specific aspects and provide justification for the methodology. The approval of my research approach by the Human Ethics Committee was imperative as it signified the research would be completed ethically and the principles of confidentiality and anonymity would be adhered to. Although this meant the study would be completed in an ethical manner if adhered to, thinking and acting ethically is an ongoing matter of research. The procedure helped to inform the way I conducted all aspects of the research from data collection to analysis.

It is also important to note in considering ethics that during this research project I was also an employee of Environment Canterbury, the regional authority for Mid-Canterbury. This was significant because although the research was not completed for the authority and the information was unavailable to them, I was still an employee and representative of the organisation. Therefore, I had to ensure that participants were aware I worked there, but also aware that the research, other than the publication of the thesis online, was not available to the regional council.

4.2.3. Fieldwork

During the period I collected data, I based myself in central Ashburton for most of the time. This was for practical purposes. It meant that generally, I did not have to travel for more than 50 minutes to get to an interview location. It was also beneficial because if an interview time needed to be changed, I could adapt to such changes. As I grew up in Ashburton, I was familiar with the area and had a range of connections within that were useful during the research process. During the fieldwork process, I was also introduced to new places within the district I was not very familiar with.

Respondents for the research were recruited based on prerequisites. A participant was required to have farmed within the Ashburton district for at least five years, and be currently farming there. This was because vulnerability and exposure-sensitivity vary over time and space; farmers currently operating within the area were aware of the current sources of exposure and contextual factors that affect their operations (Adger, 2006). The timeframe also meant there could be participants who had farmed within Ashburton for a

short period versus an extended period. This provides an understanding of whether there was a difference in perception based on the length of time people had farmed in the area. These prerequisites meant I had a range of respondents with different characteristics and experiences.

Respondents were recruited through snowball and convenience sampling. Snowball sampling refers to the referral of people of interest by other people (Valentine, 2005; Stratford & Bradshaw, 2016). The starting point of my snowball was based on the pre-existing connections I had within Ashburton. I used three different starting points. This included a dairy farmer referred to me through an agricultural business I had contacts with, a seed supplier, and an arable farmer suggested to me from an Ashburton organisation. This was beneficial as it meant respondents were not confined to the same network of people and thus I would get a range of perspectives. Networks were established through my relationships with others in the district including friends, family and professional networks.

I found it challenging to identify sheep farmers within the district. This was likely because my networks were constructed around activities sheep farmers were less involved in. This was also likely because the networks I had were confined to the Canterbury plains and sheep farmers were predominantly located in the high country. As a response, I was given the contact details for a stock agent, and they referred sheep farmers to me.

The remaining respondents were selected by convenience sampling and this selects respondents based on accessibility (Stratford & Bradshaw, 2016). The combination of both sampling methods and consciousness ensured that the location of farms was distributed over the Ashburton district. In considering the distribution of respondents, it was essential to consider how the variation in physical environments including the soil type, proximity to the coast, and rainfall. These factors influence the suitability of a farm system in an area and influence what a farmer can do. The environmental and physical setting of Mid-Canterbury is discussed in detail in Chapter Three. Figure 4.1. provides the approximate location of each farm respondent.

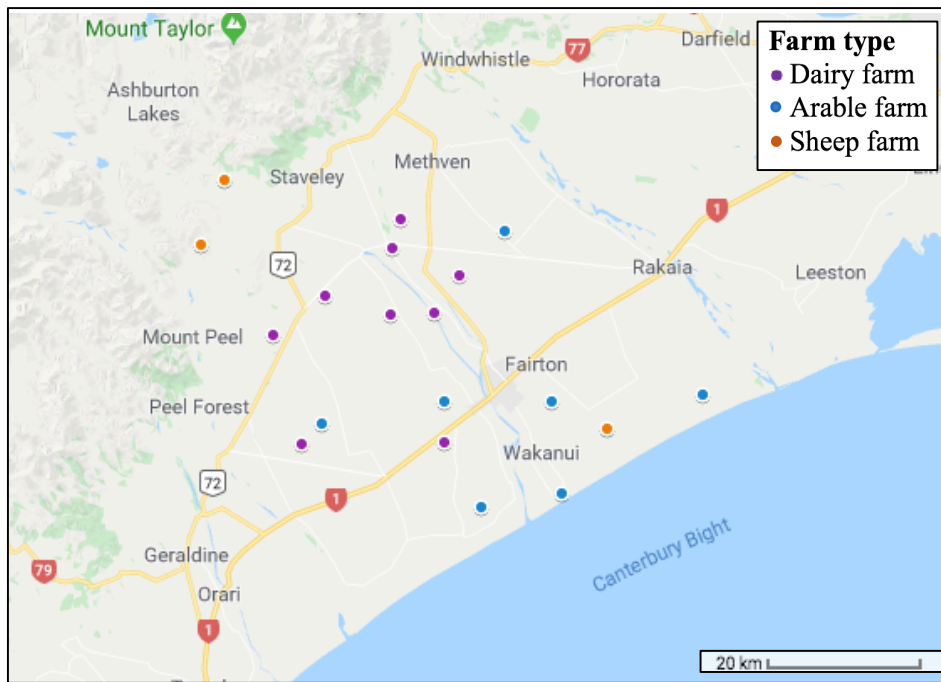


Figure 4.1. Approximate location of interview respondents within Mid-Canterbury (Google, 2018)

Before I was given the contact details for a potential respondent, the referrer contacted them. This was completed to ask them if they would be willing to be a participant in my research. The primary reason for utilising this approach was to ensure the referrer was not giving me contact details to people who did not want to be contacted. It also guaranteed that the research was conducted ethically. This was valuable because it meant that only people who were interested in helping me were referred to me and this saved me time.

After a respondent was referred to me, I would contact them, introduce myself, the purpose of my research and what is required through participation. Following this, if a respondent was still interested I would request their contact details to send them the information sheet, as provided in Appendix 1, and set up a suitable time for an interview. As this was the first point of contact with the interviewee, it was the first step in developing a good rapport with the respondent. Participants did not receive any reimbursement; it was a goodwill gesture on their behalf, and I am very grateful for that. Although there was no reimbursement, farmers were given an opportunity to express their opinions. Many of whom expressed they were appreciative of this because they are not always given a platform to be heard or understood.

In total 19 respondents were interviewed. The sample population was based on the number of dairy, arable and sheep farms in Mid-Canterbury. As reported by Statistics New Zealand (2012) there were 378 dairy farms, 210 sheep farms and 294 arable farms. The arable farm category also included other grain growing, other crops and outdoor vegetable production (Statistics New Zealand, 2012). The combination of these three types was appropriate as farmers interviewed fell into these categories. In total, nine dairy farmers, seven arable farmers and three sheep farmers were interviewed. The sample size was considered to be suitable, as there is a point where very little new evidence is obtained from each additional unit (Ritchie & Ormston, 2014). During the interview process, it became apparent that farmers within the same farm system group have similar concerns and opinions. The sample size was suitable because as the interviews progressed there was limited new information being gathered after each additional interview.

It must be noted that as the last agricultural census was conducted in 2012, the total number of farms in each category is likely to have changed. For example, Dairy New Zealand reported that in the 2015/16 season there were 405 herds in Ashburton (DairyNZ, 2017b). Therefore, there must be slight caution with the use of these census statistics.

Upon arriving at a respondent's house, I would have a discussion with them to get to know them before beginning an interview. This helped to establish a rapport with the respondent. Before an interview began, the signed consent of the respondent to conduct the interview was obtained. Permission signified that they were aware of what was required of them. Obtaining consent also involved a discussion about whether they were comfortable with the use of a Dictaphone to record the interview. The consent form used in this research is seen in Appendix 2. A Dictaphone was utilised so I could fully engage in the interview and allowed the interview to flow like a conversation. It was also important when it came to transcription of the information.

Prior to the fieldwork commencing, the interview script was piloted with a dairy farmer operating in the Selwyn area, and he had previously farmed within Mid-Canterbury for approximately ten years. This allowed me to see if the terminology and interview structure used was appropriate. During the pilot phase, it was assumed that the variability between farmers from different farm types that would be encountered during the interviews was not

significant at the pilot phase. This was because the semi-structured nature of the interviews would allow the differences between farm types to be captured based on the additional questions asked and points of interest to be elaborated on. This was also because semi-structured interviews develop based on the views of the respondent, and these were unlikely to be homogeneous across the region. Following the pilot interview, the baseline questions were slightly altered.

The structure of the interview shifted from more general and easy to answer questions, to questions that require more-in-depth reflection. The following section provides an overview of the semi-structured interview structure used and it can be split into five sections that were shaped by the research objectives:

- (1) Farm history and farmer characteristics.** This information was valuable as it would provide information about the farmer and their farm operation, and would provide opportunities in the data analysis stage to understand whether there were differences relative to different characteristics. It was also an opportunity to gather more information about the case.
- (2) The factors and context that contribute to a good and bad year of farming.** This discussion helped to illustrate the context that was affecting farmers and the other challenges and opportunities they are also required to respond to. The identification of contextual factors helps to provide information about adaptive capacity and vulnerability. These have been discussed in detail in Chapter Three.
- (3) Current and future climatic challenges and opportunities.** This section allowed farmers to identify what the current challenges and opportunities posed to them, as well as, what they believe will be issues in the future. This section provides insights into the existing and future vulnerabilities.
- (4) The adaptive measures that have been used or could be used.** This section provides information about how farmers have responded to a climatic event or

condition, and what they believe could be used into the future. This provides insights into adaptive capacity.

(5) Perceptions of climate change. Perceptions of climate change provide information about what farmers believe causes climate change, the urgency to act and the role of the agricultural sector.

It is important to note that questions relevant to any section could be explored at any stage during the interview if it was considered appropriate given the responses of the participant. After all questions were asked, I asked the interviewee if they had any additional information they would like to add before I closed the interview. Following this, I thanked the participant for the time they had given me and often had a small discussion about what I wanted to do following the completion of my Masters and other general topics.

Interviews were conducted between June and September because this was a quieter period for farmers. Interviews with dairy farmers were the initial focus to have completed during June and July, as calving began in much of Mid-Canterbury during July and August, and this would reduce the availability of farmers. Following this, arable and sheep farmers were the focus. Some arable farmers were busy during July and August because they had dairy grazing on their farms and during this period they had to get cows back to their original farms. It was essential to have an awareness of the time constraints that farmers had and the timing of their activities to be able to establish relationships with farmers. Other than this, I did not encounter any issues during the period I conducted interviews.

It was vital that I was flexible in terms of availability for interviews and aware that there could often be unintended events may require an interview to be rescheduled. Most interviews were conducted at the respondents' home. In some situations, it was more suitable for an individual to meet me in town if they had to be there. I found that it was valuable to contact the farmer the day before the interview to make sure it was still suitable, and if not find an alternative time. During the period interviews were conducted, there were two weeks when I had to postpone interviews based on the weather. This included snow around the 12 July 2017 and surface flooding and heavy rain around the 20

to 22 July 2017. These circumstances made it difficult to drive and increased farmers' workload. Thus, interviews were postponed for a more appropriate period.

In the following month after the interview, the interview was transcribed and returned to the participant. Returning the transcript provided opportunity for the participant to revoke any information or add anything additional. In one instance, a respondent corrected one piece of information. Otherwise, I have not had any responses from participants. This was an important step to ensure research continued to be conducted ethically and increases credibility. Transcription allowed me to re-familiarise with the content discussed. During this process, I made notes about any significant themes and points of interest so that when I got the data analysis stage, I could go back to these notes.

Throughout the fieldwork process, I became more familiar and aware of recurring terminology. This helped to improve my understanding of different farming practices, and this has been beneficial in shaping some of the additional questions asked to other respondents. During the interview, it was essential to be aware of the language respondents used so that I could slightly alter the language I was using to suit the participant better.

4.3. Reflexivity

During the research process, the principle of reflexivity was adhered to and recognised; this involved considering my positioning in the research, the pre-conceptions associated with the research and scrutiny of myself as a researcher. Reflexivity can be difficult because people are not accustomed to scrutinising their engagement with their work at the same intensity we regard our research topic (Dowling, 2016). Reflexivity involved considering how my background, assumptions and behaviour impacted the research process (Hennink, Hutter, & Bailey, 2011). The following section discusses and acknowledged some of the components that I reflected on as part of my research.

4.3.1. Fieldwork

Conducting semi-structured interviews was a new and insightful experience. Methods I had previously used in other projects when engaging with communities included surveys and focus groups. Through conducting participatory research, my belief regarding the

benefits of conducting research with people to better understand their values and ways of seeing the world was reinforced.

It was essential to note that no matter how neutral I wanted to be, my own experiences and knowledge of climate change affected my ability to be impartial. It was critical to be conscious and mindful of this and not to force my opinions upon others. People were willing to express their thoughts when they are treated with respect and were grateful their opinions were heard. I believe that the approach I took during interviews allowed an honest account of participants' opinions and views to be collected.

During fieldwork, it became evident that relative to a farmer's location within Mid-Canterbury, people experienced very different challenges and opportunities based on the physical environment affecting their agricultural practice. This meant I could not assume which contextual factors were of relevance to a farmer before I discussed this with them. Being aware of how location can affect perspectives was critical.

4.3.2. Ethics

The research was completed in an ethically. One component was seeking permission to record the interview. Respondents were willing to do this when they were aware that the interview recording would not be available to anyone other than myself and supervisors. Gaining informed consent was essential to establishing a good rapport with participants and said a lot about myself as a researcher.

Ensuring confidentiality and anonymity were significant ethical components. Participants were assured no names or identifying material would be used. Each participant was allocated a code based on their farm type and response number. This coding method ensured anonymity and confidentiality. Anonymity was discussed with some of the respondents prior to the interview commencing, highlighting this was a priority for some participants.

Climate change can also be a polarising topic of discussion amongst people with different opinions. I had previously had conversations with people who had different perspectives to my own on climate change and therefore was aware how there are many differences in

opinion. It was essential to recognise this and ensure that the discussion was inclusive and respectful rather than polarising.

4.3.3. Seasonality and extreme weather events

Perspectives relating to climate change can be affected by extreme events, seasonal and annual patterns, rather than long-term changes (Thomas, Twyman, Osbahr, & Hewitson, 2007; Mertz et al., 2009). During the period I conducted interviews, many respondents noted how wet the current year had been already. It is critical to be mindful of how current weather trends may affect perceptions. Therefore, the research findings may be affected by the floods that occurred between 20 and 22 July 2017. Of notable significance, during this period some farmers had begun calving, and they noted that it was harder for calves to stand up in the wet so they would have to be out at all hours through the day and night to ensure that they minimised losses. For other farmers, they were required to move stock, fences and feed stock more. However, only six interviews were conducted after this event, therefore, it is unlikely that this will have a substantial effect on the data collected, but it is still important to consider how those conducted after the event may have slightly different concern for heavy rainfall events relative to those undertaken before.

Another noteworthy weather event was the snow that occurred on the 12 July 2017. Although it is unlikely that this would have a large effect as it was not an unusual event, it provided valuable insights into how farmers can prepare for and respond to weather events that they are not necessarily exposed to every year. The responses to and preparation for the extreme rainfall event also provided valuable information that may not have been captured if the research was conducted at a different time of year.

4.3.4. Politics and the 2017 election

During the period, I conducted interviews the 2017 election campaign was happening. The Labour Party announced a possible ‘Water Tax’ with farmers describing it as worrying as there was little information available on the exact nature of the policy. The Labour Party stated that a working group would be created to determine this relative to whether they were successful in the election or not. It is likely that the election highlighted contextual factors that may not be considered if it had been a different year. Different respondents

discussed different contextual factors that were related to both the National Party's and Labour Party's policies. The policies discussed were often those receiving more attention within the media. As all my interviews were conducted before the change in government, this does not capture the feelings and opinion following the election, but it does capture the uncertainties that become an issue during the election campaign.

4.3.5. Power relations

Interviews are interactions between two people and occur within societal context and are affected by societal structures, norms and power relations (Dowling, 2016). When conducting an interview, it was important to realise that the power dynamics that existed between myself and the respondent. Reciprocal relationships describe the researcher and respondent being in similar social positions and experience similar benefits and costs from participation in the research (Dowling, 2016). In contrast, asymmetrical relationships are characterised by those with significant disparities in the social position of the researcher and the participant (Dowling, 2016). I do not believe there was an unequal power relation between myself and the respondent. The respondent and myself both benefitted through the research process. I could collect meaningful data to improve my knowledge about climate change and adaptation, and the respondent could express their opinion openly.

I also shared a common interest with the respondent as I grew up in Ashburton, and still had ties to the area despite not now living there permanently. Therefore, I was part of the community and understood the district. This allowed me to relate with the participant (Valentine, 2005; Hesse-Biber & Leavy, 2006). It is also important to be aware of the relationship between rural and urban communities. I had to be mindful of the way this relationship is portrayed within the media, and because I was from an urban area myself rather than a farming background I had to be aware of this tense relationship. It was critical to be open-minded and not to let any preconceived ideas influence the questions I asked. Part of the issue between the rural and urban communities is due to a lack of communication between the two groups of people. Therefore, I also felt that I was helping to bridge this gap.

4.3.6. Identity

The way people treated me as a researcher was shaped by being a university student and an employee of the regional council. Some people resonated with my identity as a university student as they had children who had been to university or they had been to university themselves. However, it was also a point of difference between myself and my respondents as I was a current student. It was essential to be aware of this in the interview process as it shaped our interactions and because I was there with a purpose of gathering data (Hoggart, Lees, & Davies, 2002). With being a university student, there was a difference in age between myself and the respondent ranging between approximately ten and fifty years. Therefore, I needed to speak in ways appropriate for my respondents rather than how I would communicate with my peers. In recognising the differences in age, it was also clear they have many experiences that I had not had, and this provided valuable insights into events that I could only imagine, such as the reforms of the 1980s.

My identity is also shaped by being an employee of Environment Canterbury. I had to be aware of how people perceived me as a regulator. Farmers have many interactions with Environment Canterbury for resource consents, farm environment plans and consents to farm. I had to make farmers aware that the data collected would only be used for this thesis rather than available to the organisation, and this was important to establish trust and a good rapport between myself and the participant. Despite this, at times respondents seemed to be a little bit hesitant discussing topics such as water due to my relationship with the organisation. This meant respondents might not have expressed all their opinions on certain topics. However, as I sought to develop trust and positive relationships with respondents throughout the research process, I believe this would have had minimal effect on the collection of data. This was very important to consider throughout the research process as I wanted to collect meaningful data that was not affected by peoples' associations with the organisation.

4.3.7. Gender

The respondents of my interviews were mainly males. In six interviews I had two respondents, and in five of those, there was one male and one female respondent. In no interview did I ever speak to only a female respondent. In New Zealand, there is a

significant number of males employed in the agricultural sector, and there is also a notable number of females (Statistics New Zealand, 2015). In Canterbury in 2016, 8,000 females were employed versus 17,400 males (Statistics New Zealand, 2017a). My sample population did not capture the representation of gender. It is valuable to recognise this because generalisations cannot be made about both males and females from the research, as it cannot be assumed that they have the same perspectives on the issues discussed (Eichler, 1991).

There have been increases in the number of women in the workforce and the agricultural sector as a result of changing societal norms, and conditions allowing women to enter the work force (Johnston, 2005). Since 1984, approximately 70% of farms produced some of their income from off-farm sources (Smith & Montgomery, 2004). There has been an increase in women in off-farm employment, from 8% in the 1960's to 25% in 1991, and this trend can be seen to have continued to increased today (Smith & Montgomery, 2004). Many respondents expressed that their partner or family members who were female were involved to some degree in the operations on the farm, whether it be book work or light manual labour. This was captured in interviews where there were male and female respondents.

In the situation of a male and female respondent, it was essential to consider the dynamics operating in this specific interview between the male and female respondent, but also within societal structures. In society, men often talk more than females, and this can also be a generational aspect (Dowling, 2016). Males were the dominant voice in the interview responses. Females articulated similar answers to the male, made corrections to their statement or provided further detail about the topic of discussion. It was important to provide opportunities for both males and females to speak their opinion.

It was also critical to recognise the role of my gender in the research project. There is evidence that if the respondent and interviewer have different genders, the data collected from the interview is different than if the gender of the two is the same (Seidman, 2006). As interviews are not separate from society's attitudes, structures and roles, it can be assumed that an individual's attitude and behaviour towards gender could affect the way I was treated by a respondent. Although it is important to recognise my gender, I believe my

age and current identity were more significant in the way respondents treated me. Males and females treated me similarly, and the only notable difference between how males and females treated me was that females would often be first to offer me a drink in their home.

Past female researchers that have interviewed males have noted that interviews often follow the usual female-male verbal interactions, and they facilitated the flow of male's conversations (Winchester, 1996). However, as the interview was semi-structured I had more control over the questions that were asked and the topics that were probed, which disrupted this general notion and tried to facilitate a more even conversation. Gender was also essential to consider in the interpretation of the data collected, as in data analysis is not undertaken separately to societal norms and structures. I must be aware of my difference in gender as well as expertise, age and knowledge. As I developed good relationships with participants, I believe that I captured the most meaningful information that was available to me and that the information could be represented appropriately.

4.4. Data analysis

The data analysis requires making meaning from the information gained through the interview process. The first step to being able to draw meaning was to transcribe the interviews. During the transcription process, I made notes of some themes and interesting points encountered. This was helpful because the period I transcribed over was three months, and this meant that as I transcribed different interviews, I could see if there were reoccurring themes between interviews.

The data collected from the interviews were analysed through latent content analysis. This process assesses implicit themes within a text and may include ideologies, beliefs or stereotypes (Dunn, 2016). This identified topics relating to climatic challenges and opportunities, adaptive measures, climate change and the context that affects agricultural producers. As well as, recognising how these components affected adaptive capacity and vulnerability. The latent content analysis also involves coding relative to different factors such as farm type, supplier, the age of respondent and education to understand if there are any marked differences based on these categories.

I completed multiple readings of the transcripts to ensure I was familiar with the data. After initial notes were made during the transcription process, I reread the transcript and made further notes. During this process, important quotes were also highlighted in the transcript that might provide further information and a point of discussion.

Relative to each research objective, the coding process was split up into four sections that aligned with four of the five sections of the interview:

- (1) **Contextual factors** that contributed to a good or bad year of farming.
- (2) The **current and future climatic opportunities and challenges**.
- (3) The **adaptive measures** that are used or could be used in the future including:
 - a. Short-term measures
 - b. Medium-term measures
 - c. Long-term measures
- (4) **Perceptions of climate change** including causes, responsibility and need to act.

It was beneficial that the interview questionnaire structure was split relative to the themes used in coding the transcripts. However, it was critical to review the entire transcript for each theme due to the semi-structured nature of the interview. The coding process allowed me to summarise transcripts ranging from 20 to 35 pages into approximately four to six page summaries and made the information a lot more manageable.

The coding process also provided a way to identify similarities and differences between different farmers. Different groups were formed and commonalities, differences and irregularities between and within groups were noted. This involved a physical cut and paste approach. Word documents and tables were created and information was grouped relative to different groups and different research objectives. The groups included in the data analysis stage were based on the first part of the interview and included:

- (1) Farm type: Arable, sheep, dairy.

- (2) Age: 40 and below, 41 to 50, 51 to 60 and above 60. These categories were considered appropriate to illustrate if there were differences relative to different ages.
- (3) Education: Whether the farmer had attended tertiary education. Education categories were created to see if there were differences based on education.
- (4) Supplier: Fonterra or Synlait. These categories are only applicable to the dairy sector. Arable and sheep farmers did not supply a specific supplier. Therefore, supplier categories could not be easily distinguished for the arable sector.
- (5) Location within Ashburton: coastal, inland, high country, Methven. These categories illustrate how perceptions, challenges and opportunities and the context operating varied relative to the location within Mid-Canterbury.
- (6) Length of time within Ashburton: Less than ten years, ten to thirty years or their whole life. These categories aimed to see if there were differences based on the length of time one had farmed in the Ashburton district.
- (7) Ownership: Family owned, sharemilker or worker. This was to see if there were differences based on ownership.

After the interview transcripts were coded, I went back through the transcripts and identified quotes that related to each theme and illustrated a point well, and removed these from the transcript. These provided quotes of interest that would support the key themes in the research. While quotes were a valuable source of data, it was critical to be cautious that when drawing them out of the discussion they were not interpreted outside the scope of the conversation they were spoken in. The transcripts were read a final time to make sure that no valuable information had been missed. As I read the transcripts multiple times, I had to be mindful not to reshape the meaning of the opinions expressed.

Chapter Three presented additional information related to the context affects farmers. This included the climate projections related to the area from the Ministry for the Environment (2016) and Bright et al. (2011), and these projections were used to understand if farmers were aware of the likely changes. Multiple sources of information helped provide a greater understanding of the cases in this research. Finally, the data analysis stage involved writing a summary of the findings and results, which can be viewed in Chapter Five.

4.5. Conclusion

This research utilised a qualitative to achieve the research objectives. The literature review was fundamental in developing the research, methodology, and situating the research within the existing literature. Fieldwork was undertaken within Mid-Canterbury, New Zealand and involved conducting interviews with dairy, arable and sheep farmers. During and after fieldwork it was important to reflect on and scrutinise my positioning as a researcher and the preconceived ideas I had. Reflection also provided an opportunity to consider current factors that may have influenced data collection. Finally, the interview data was analysed. This required transcription and the coding of the interview transcripts provided an opportunity to create meaning and understand commonalities and irregularities between different farmers and farm systems in Mid-Canterbury. The findings from this research methodology and the implications of these findings make up the remainder of the thesis.

Chapter Five: Understanding the effects of climate change on agricultural producers Mid-Canterbury

“Climate change, that is a huge variable for farming, and we don’t really know, or understand too well perhaps what the effects of that could be”

- Dairy farmer, Mid-Canterbury

5.0. Introduction

This thesis aimed to explore how climate change will affect dairy, arable and sheep producers in Mid-Canterbury. This chapter will present the results of the methodology described in Chapter Four and summarise the opinions that were expressed by farmers during the semi-structured interviews. Firstly, the characteristics of the farmers and farms used in the sample will be introduced. This includes the environmental and physical setting producers operate within. The current and future sources of climate exposure are discussed. Next, the contextual factors that shape vulnerability and exposure-sensitivity are examined. The adaptive strategies that have been or could be used in the future are reviewed. Finally, perceptions of climate change will be identified. The discussion reveals a range of commonalities and differences that exist between individuals and sectors within Mid-Canterbury and provides an assessment of how climate change may affect producers.

Through the chapter, each quote will be accompanied with a code that represents the farmer that said it. The letter of the code refers to the farm system. D signifies dairy farmers, G for arable farmers and S for sheep farmers. The number associated with the code represents the number respondent they were for that farm system.

5.1. Farmers and farm characteristics

5.1.1. Farmer characteristics

The research interviewed 25 respondents from 19 farms within Mid-Canterbury. Table 5.1 identifies the number of farms, farm types, interviewees and gender of participants. The age of respondents ranged between 31 and 74 years, and sixty-percent of respondents were older than 50 years. Table 5.2 provides the age distribution of respondents. Participants were either the farm owner, sharemilker or a worker and 18 people had lived in Mid-Canterbury for their whole life. Two participants had been in the district for approximately

30 years, and the other five had been in the area for less than ten years each; these respondents had farmed elsewhere before moving to Mid-Canterbury. Some respondents had left for short periods of time to farm elsewhere or attend tertiary education. Eleven individuals had a tertiary qualification; however, they were not all agriculture-related.

Table 5.1. *The number of respondents from each farm system and their gender*

Farm type	Farm number	Respondents	Male	Female
Dairy farms	9	10	9	1
Arable farms	7	10	8	2
Sheep farms	3	5	3	2
Total	19	25	20	5

Note. Adapted from: Research findings

Table 5.2. *The age distribution of respondents from each farm system*

Farm type	Less than 40	41-50	51-60	61+	Total
Dairy farms	5	1	3	1	10
Arable farms	1	1	4	4	10
Sheep farms	2	0	2	1	5
Total	8	2	9	6	25

Note. Adapted from: Research findings

Most of the arable and sheep farms were family-owned and had been in the family for more than one generation. Five dairy farms were family-owned. Four of these had changed their production system from sheep, beef and cropping to dairy within the last 20 years. The fifth farm was converted to a dairy operation after it was purchased. The remaining farms had sharemilkers. The farmers who were not from Mid-Canterbury were motivated to move to the area due to the opportunities that were present.

5.1.2. Farm characteristics

Figure 5.1 shows the distribution of the farms in Mid-Canterbury, and the different soil types. The New Zealand Soil Classification (NZSC) Soil Order represents the most generalised classification for New Zealand soils; and these are further divided relative other characteristics including drainage capacity and permeability (Landcare Research, 2018b). Soil types varied relative to the proximity to the river, coast and hills.

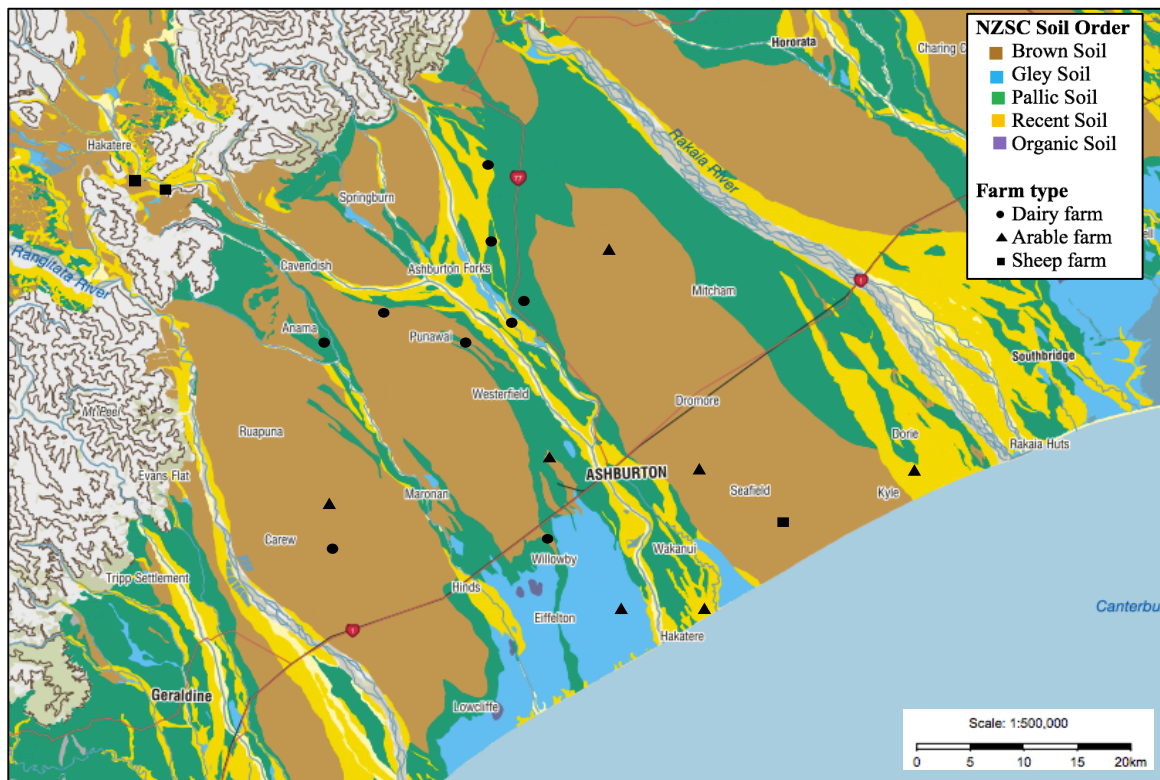


Figure 5.1. Variation of soil types within Mid-Canterbury and location of interview respondents (Landcare Research, 2018b)

Dairy

The size of the dairy farms ranged between 70 and 500 hectares. Most soils were well-drained or moderately-well drained, and the farms located beside the river had variable soils. All but one farm were purely dairy operations. This farmer also produced vegetable seeds on their property. All dairy farms were fully irrigated and used groundwater or surface water. There were small variations in precipitation, and farmers closer to the hills received more annual rainfall than those further away. D05 stated he added irrigation to his previously sheep and cropping farm in the last six years because he believed irrigation was necessary to “utilise the land to its potential”. The company each dairy farm supplied their milk product to is visible in Table 5.3. Three Synlait suppliers were from family-owned farms, and one was a sharemilker. One Fonterra farm was family-owned, and two were sharemilkers.

Table 5.3. *Dairy companies’ farmers supply*

	Number of farms
Fonterra	3
Synlait	4
Not disclosed	2

Note. Adapted from: Research findings

Arable

Arable farms ranged between 120 and 540 hectares and were all located on the plains. Well-drained soils comprised most of the farm area. One farm beside the coast had poorly drained soils because the land was historically swampland, and those situated by the river had variable soils. Production included a combination of crops that were generally rotated over a five-year period. Dominant crops included wheat, barley, maize, ryegrass, vegetables for seed including radish, and carrots. Some farmers produced peas and potatoes for consumption. The three farms located near the coast expressed they could be affected by easterly winds. This could make getting in the harvest difficult because the easterly wind would pick up moisture from the sea and add moisture to their crops. Four farms also used their land for dairy support and winter grazing. G03 said, “we have 100 acres of river bed which is just shingle, which is great for grazing cows in the winter”. The remaining farms had some stock because it provided another source of income and could act as a restorative phase in their crop rotation. All farms were fully irrigated.

Sheep

The size of sheep farms ranged between 200 and 4250 hectares. The farm located on the plains was partially irrigated and had well-drained soils. The other two farms were in the high-country and had variable soils and altitudes which made their management strategy complex. High-country farmers had water reticulation systems to distribute water throughout their farm. These farms were exposed to a variety of climatic conditions that farmers on the plains were not regularly affected by including snow. High-country farmers also received higher annual precipitation. Farm activities included intensive sheep and beef farming and finishing. All farms had both sheep and beef stock, and the farm on the plains also had deer.

5.1.3. Summary

Farmers and farms within Mid-Canterbury exhibit a range of characteristics. There is variability in what dairy, arable and sheep farmers do and where they operate relative to the physical and environmental setting.

5.2. Climate

Farmers are exposed and sensitive to a range of climate conditions and events, and these vary relative to the location of a farm. This discussion will highlight the components of the climate that producers identified as significant. It will also examine what farmers perceive as challenges and opportunities in the future, and relate these to the projected changes for the district. Table 5.4 provides a summary of the climatic factors and their impact as identified by producers in Mid-Canterbury.

Table 5.4. *Summary of the climatic sources of exposure for dairy, arable and sheep producers within Mid-Canterbury*

Source of exposure	Impacts		
	Dairy	Arable	Sheep
Good weather (warm; adequate precipitation)	Good pasture growth and production	Good crop growth and yield	Good pasture growth
Extreme precipitation	Pugging; Negative impact on pasture growth	Negative impact on yield and growth	Negative impact on pasture growth
Drought conditions	Reduced feed; Impose water restrictions; Higher expenses	Increase water demand; Reduces growth if cannot keep up with demand	Reduced feed
Cloudy weather	Cows do not milk as well		
Snowfall			Affects animal health
Hail		Damage to crop; Reduce yield (long-term)	
Strong winds	Wind chill	Damage to crop; Reduce yield	Wind chill
High temperatures	Heat stress	Heat stress; Reduce yields; Increases water demand	Heat stress
Minimal consecutive hot and dry days		Difficult to harvest	
Frosts	Removes pests and diseases	Remove pests and diseases; Late frosts reduce growth and yield	Affects pasture growth
Changes to seasons	More feed; Milk for longer	Affects growth	
Nor-west wind		Increases water demand	

Note. Adapted from: Research findings

5.2.1. Current sources of climate exposure

Farmers from each farm system emphasised different climatic features as being more significant sources of exposure. Water is the most vital component for dairy farmers. In periods of low rain, farmers use irrigators to fill water deficits, and six of the dairy farmers expressed they are more productive in dry conditions if they can irrigate. D01 said, “droughts don’t affect us, we just pump the water on”. Irrigation allows dairy farmers to control the amount of water applied to pastures, and this helps to maximise productivity. Two farmers commented on the high costs associated with accessing water. D03 stated it cost \$50,000 to buy into an irrigation scheme, and \$150,000 to set up a 60-metre deep well on their farm. Despite this, most dairy farmers wanted to utilise irrigation as they had invested a lot of money in it and wanted to get a return on this investment. Water is essential for dairy farmers, and there are high costs associated with this.

In contrast to dairy farmers, arable producers expressed that they are reliant on multiple aspects of the climate including temperatures, water and extreme events. These affect the growth and quality of crops. G06 emphasised that, “seeds and cropping are reliant on the weather playing its part” and G01 said, “given the wrong conditions I could lose 80% of our income after growing it for 12 months”. In comparison to dairy and arable farmers, sheep farmers have limited or no ability to irrigate or manipulate the climate. Instead, they are required to farm to ‘the conditions’. Critical aspects for sheep farmers include precipitation, temperatures and extreme events, and high-country farmers are also concerned about snowfall. The significance of a climatic factor varied relative to the importance in a practice and the way it could adversely affect their production.

Producers were more sensitive and exposed to the climate at different times of the year. Multiple dairy farmers expressed wet conditions during spring are the worst. This is because they risk pugging their paddocks. Pugging compacts and damages the soil which lowers productivity. The occurrence of hail, extreme winds and rainfall events are critical during spring and summer for arable producers because they can damage crops and reduce yields. G03 said, “you can lose hundreds of thousands of dollars just with a major rain storm or big wind”. Sheep farmers expressed they were most vulnerable during summer because droughts are probable during this period. Droughts impact feed availability, and the condition of lamb when sold. All systems are sensitive to droughts, however, the

significance of this varied relative to if farmers had irrigation or not. The periods of exposure and sensitivity were significant because they affect productivity and financial return.

Farmers also identified periods in which they noticed a reduction in their productivity relative to the climate and this related to the period their financial return was based over. Dairy farmers were concerned about the climate within each month. D04 specified, “you are getting paid the 20th of every month”. The financial return for a dairy farmer was reflective of the climate and how it affected their productivity within that month. Sheep farmers were concerned relative to seasons. Summer conditions were critical because they would influence the stock quality and the payout. Sheep farmers sold their other stock during different seasons. In comparison, arable farmers operated within a longer-period, and often this was 12-months. G01 said, “we sow most of our crops here through February until the end of May and then harvest from January until April, it is almost 12-months. In that time, we are exposed to a variety of climates”. Many arable farmers stated that they had included dairy grazing in their operations for economic security. The climate influences the payout, and each sector was more concerned about the climate within the specific timeframe that affected their financial return.

Periods of extreme heat and rainfall were significant for all producers. G01 commented that, “when they are sitting as a seed below the ground, they are quite exceptionally vulnerable, when they shoot up, they are slightly less vulnerable”. Heavy rainfall can drown and rot seeds. Arable producers also expressed that when it is too hot, there is a cooking effect on the plant which affects productivity. In the extreme wet dairy and sheep farmers can waste a lot of feed. Excessive heat and overcast weather can minimise milk production. Farmers also commented that strong and cold winds in winter affect stock health. These factors influence productivity and financial return. All farmers were aware of the variability of the climate and G07 said, “the variability of the climate has an influence over what we do”. Farmers expressed that it could be a nuisance and complicate management.

5.2.3. Future sources of climate exposure

Climate change is projected to alter the climate in Mid-Canterbury, and these changes are summarised in Table 5.5. Sheep and arable farmers were aware that changes to the existing climate would impact their practice. G01 expressed that, “if they [changes] were too great and significant, then we would have to change what we are doing”, and S03 said, “we need to be aware that there will be significant further implications for this property with climate change”. However, there was a general unawareness of what ‘significant’ changes would constitute. In contrast, dairy farmers did not suggest it would have significant implications for their practice other than they may need to find alternative ways to store water. A change in water availability, temperatures, and extreme events would exacerbate the current impacts faced, and alter farmers’ exposure-sensitivity and vulnerability.

Table 5.5. *Summary of climate change projections for Mid-Canterbury*

Variable	Projected change
Temperature	Increase by 0.7-1.0°C by 2040
Annual precipitation	Increases of up to 400mm in the headwaters and little changes on the plains Potential seasonal changes with the most significant for the headwaters in spring and winter
Extreme rainfall	Increase in the magnitude and frequency of heavy rainfall events
Drought	Increase in the number of days exceeding 25°C Time spent in drought will double or triple by 2040
Winds	Westerly winds are projected to increase by 10% by 2090 compared with 1990 with significant increases in winter and decreases in summer and autumn
Volatility	Increase in volatility
Storms	Severe weather systems are projected to increase by 3 to 6% over most of New Zealand by 2020-2100 relative to 1970-2000
Frosts	Reduction in the number of frosts and nights below 0°C

Note. Adapted from: Mullan, Stuart, Hadfield, and Smith (2010), Bright et al. (2011), Clark et al. (2011) and Ministry for the Environment (2016)

D08 commented, “there is definitely risk for Canterbury if rainfall decreases and we don’t recharge aquifers and can’t irrigate. That would cripple the system”. Other dairy farmers echoed these concerns because they are reliant on water for their pasture-based systems, and this provides them with a competitive advantage internationally. D04 said, “we don’t want to be using them [irrigators] all the time because of electricity costs”, and expressed they spend approximately \$44,000 per year in electricity costs for irrigation. Arable farmers also expressed concern about the high costs associated with irrigation. The

projected changes in rainfall for Canterbury are variable and include increased precipitation in the headwaters, decreased annual precipitation and a notable decrease in winter; this could be problematic for aquifer recharge and irrigation reliability if there are not alternative methods to store and move water (Ministry for the Environment, 2016). Farmers also conveyed that an increase in maximum temperatures would increase heat stress and alter stock performance.

All sheep farmers stated they would be concerned if precipitation decreased substantially. This is because they require rain to support their system. In the headwaters, it is projected that there will be an increase in precipitation and this may create unintended impacts for these farmers (Bright et al., 2011). The sheep farmer who had some irrigation echoed similar concerns to dairy and arable farmers about irrigation reliability. S02 commented that an increase in extreme wind, snow and rainfall events would be a “nuisance but are unlikely to bugger our business”. The other sheep farmers also emphasised this. S03 noted that milder winters and earlier springs would be beneficial because they would help increase productivity and profitability. However, there is some evidence to suggest that warmer climates may result in more storm events due to increased moisture in the air (Mullan et al., 2010).

G03 expressed that, “if we have a significant increase in temperature it would change the way we farm”. This was because it could alter the suitability of crops grown in the area. Four other arable farmers expressed similar concerns. Changes to temperatures and north-west winds would be problematic, and some arable farmers did not believe they would be able to keep up with increased water demand of different crops. Alongside this, reduced rainfall would be problematic as it would further increase demands. The climate projections for the area correspond with these issues as seen in Table 5.5. (Bright et al., 2011; Ministry for the Environment, 2016). Other changes that would create problems included increased volatility in weather patterns.

5.2.3. *Summary*

Agricultural producers within Mid-Canterbury are aware of how the climate is one source of exposure to which their farming practice is sensitive. The climate is critical for farming, and each industry is exposed to and sensitive to different factors at various times

throughout the year; this shapes their vulnerability. The significance of a climate variable varies relative to the importance of the input for productivity, and the timing of their payout. Sheep and arable farmers are exposed to a larger range of factors than dairy farmers. Dairy farmers are primarily concerned about water availability. Farmers also identified changes in climate that would affect their farming practice, and these echoed the current challenges and the projected changes for the district. Farmers were generally unable to define what they believe constituted ‘significant’ changes in climate. A change to the climate will alter a farmers’ exposure-sensitivity and vulnerability.

5.3. Other sources of exposure

Climate is not the only source of exposure for agricultural producers. Farmers are sensitive to and affected by a range of factors as discussed in Chapter Three. The risks and exposures identified by farmers within Mid-Canterbury are visible in Table 5.6. These are considered risks because a change to one of these conditions can exacerbate or reduce vulnerability. These factors shape the sensitivity of a system, what a farmer does within their practice and their financial resources. They also often require an immediate response, and farmers expressed they consider these as more confronting than climate change. Multiple farmers stated that although the climate is essential for their operations, there is nothing they can do about it.

Table 5.6. *Examples of risks that affect agricultural producers*

Type of risk	Example
Market	Market Dairy industry prices Demand for protein Overseas climatic conditions and disease Relationship with seed companies
Financial	Interest and loan rates Land prices Cost of inputs; power; irrigation
Institutional and political	Regional council: Farm Environment Plans; nutrient limits; irrigation and water take; effluent; storage ponds Pastoral lease limits Immigration and employment laws

Note. Adapted from: Research findings

5.3.1. Market

The market was a significant source of exposure for farmers because it affected their financial return. All farmers expressed that the market and the climate were the two most important variables for their farming practice. G03 said the market is critical “so you get decent prices and good returns”, and the climate supports the production of goods for the market. Arable graziers mentioned that the downturn in the dairy sector in 2014 and 2015 bought grain and grazing prices down. Alongside this, when the dairy sector is not buying grain from arable producers it removes some of the competition, and many grain companies start paying less. Sheep farmers that supply stock for dairy cattle are also affected by the downturn, as dairy farmers do not buy new stock.

Arable producers expressed they are in a unique situation because they do not have full control over what they produce. G03 explained that seed companies “control the seed and they decide who they want to grow it”. Arable farmers can choose not to grow something if they consider it as uneconomical to produce. However, they may become reliant on being offered something else by a different seed supplier if they turn down one offer. Four arable farmers described that are required to ‘market’ their products, identify potential buyers, facilitate distribution and meeting customer needs. In comparison, dairy farmers and sheep farmers do not have to market their product, and it is done by the milk and meat processors.

Farmers are also sensitive to changes in demand, overseas climate events, pests, diseases and consumer preferences shapes this. For example, a drought in Australia can increase the demand for some of New Zealand’s products. Farmers expressed that it can be challenging to respond to these changes within a season. The market is a critical source of exposure and shapes farmers’ financial resources.

5.3.2. Financial

The market influences the financial return a farmer received, and this determines their fiscal resources available for expenses. Farmers are required to respond to changes in interest rates, cost of inputs and land prices. Some arable farmers stated they were affected by the reforms of the 1980s. G03 said they “were encouraged to put irrigation in... and the

government was lending us money at 7%”. Following this and the reforms, the interest rate on many loans increased and this farmer stated, “it had gone to 17.5% before we had even picked up the loan”. This experience shaped five arable farmers approach to financial resources, with G04 stating, “it has probably coloured my belief in borrowing”. Land prices are also crucial and have motivated system changes. G01 said, “we changed because land prices then started to increase, so we needed to generate more income to run the business effectively and efficiently, and get a return on our investment”. This farmer reduced the number of stock he had and increased the area used for arable purposes.

Farmers are also sensitive to increases in the costs associated with expenses. G06 stated that, “power costs and everything is going up, so every year you are paying more to use the irrigation, as opposed to like 20 years ago... our produce prices are coming down, and our costs are going up”. D03 said that power would cost them an extra \$18,000 a year with the expected increases. This affects a farmer’s economic resources, and farmers stated it is difficult to adjust their practice within a year to receive more income to compensate for an increase in expenses. Financial resources influence what a farmer has available for expenses and investments.

5.3.3. Institutional and political

Farmers were asked about the regulatory and institutional factors that affect them. All farmers discussed the regional council and rules regarding water take, effluent ponds, nutrient limits, stocking rates, consent to farm and Farm Environmental Plans. G03 described that, “we have a lot of things to worry about like farm environment plans and leaching plans... which are staring us in the face”. These are immediate sources of risk that require action. D08 expressed that “we are in a space at the moment where we don’t know exactly what the rules are going to be, and it is a very grey area which creates uncertainty”. This was regarding the Farm Environment Plans for the Hinds area and was critical because the farmer would have to adjust their practice relative to the rules. The sheep farms in the high-country were affected by pastoral lease limitations which affect stocking numbers and the provision of land.

The dairy sector had the most workers with some farms having nine workers. These farmers expressed that employment and immigration laws affected the ability to keep and

employ staff members. Most farmers stated they were part of a discussion group. These were helpful to demonstrate new initiatives that came available in each sector, such as more efficient breeding tools or new pasture-species. Farmers who supplied Synlait said there were specific conditions they had to adhere to through the ‘Lead with Pride’ initiative. This provides an incentive to supply to Synlait because farmers were paid more for adhering to the conditions. The scheme allows Synlait to market themselves as being environmentally and socially sustainable. D03 reported that “I have noticed a big difference between Fonterra and Synlait. The people at Synlait are just easier to talk to than the big co-operative guys”.

Many farmers attended field days hosted by organisations such as Federated Farmers, DairyNZ, Foundation of Arable Research and Beef and Lamb. Some farmers also had held field days on their properties about breeding and grass growth. S01 described that “I have had Federated Farmers trying to get me up with them, but I do not see the benefits. I am quite happy to sit down and look at the internet”. G03 said they were at a maize field day for five-star beef as they provide maize for them and it was reported that “there has been no new varieties to come out to increase our yields”. D08 expressed that they “try to get involved in them [field days] as much as we can”. Evidently, field days provide opportunities for learning for farmers. Farmers expressed they can help in exploring new technologies, choosing new varieties to grow and showing new ways of doing things. However, G03 noted that “you are not going to give all your secrets to the next person”. This was about the limited knowledge sharing amongst the arable community versus the dairy sector. Rural organisations provide options to distribute information to farmers.

5.3.4. Significance of climate risks

It is essential to consider how climate change is perceived alongside the other sources of exposure. In general, market, financial and institutional forces were more significant sources of risk than ‘climate change’. This was because they required more-timely and sometimes urgent responses. Farmers did acknowledge that climate change could have implications for their farming practice, however, they did not consider ‘climate change’ to require a pressing response and many were unaware of the magnitude of changes that were projected with climate change. They did understand that an increase or decrease in key climatic features would change their farming practice.

G05 expressed “it is more reacting to the day-to-day climate than the long-term” and that “the ‘climate change’ is not part of how we think”. G03 described it as “I guess that is probably in the back of our mind, it probably doesn’t get to the front because we have a lot of other things to worry about instead like farm environment plans... and licenses to farm... which are staring us in the face which are far more significant and far more expensive”. S03 recognised that the current practices on their farm may be suitable for the next 20 to 30 years but beyond this it is likely that they will have to make changes. All farmers would monitor the day-to-day weather and respond to this, but they did not adjust their practices to longer-term forecasts they obtained from NIWA. Generally, farmers operated within short and medium timeframes rather than long timeframes. Farmers using irrigation all commented on how a reduction in water availability would be adverse for their production, and this was the primary concern that reflected longer-term thinking associated with climate change.

5.3.5. Summary

Farmers were aware that there were multiple sources of exposure which affect their farming practice. All farmers expressed that the climate and the market were the two most important sources of exposure for their farming practice. The market was critical because it would affect their income. Although the climate was a significant source of exposure, in general, the market, financial and institutional factors were considered more significant than climate change because they required more-urgent responses. The following section will discuss the adaptive measures that have been utilised in Mid-Canterbury.

5.4. Adaptation and adaptive measures

Farmers within Mid-Canterbury use adaptive measures that respond to sources of climatic exposure. However, it is rare that responses are only to climatic stimuli. The options for adaptation that farmers expressed they utilised were to ensure their productivity and financial returns, and minimise expenses. Adaptive responses also occur within the institutional framework that influences what farmers can do on their farm and within their practice. Producers monitor the weather and adjust their management relative to the anticipated conditions, or in response to an event or condition. Farmers have implemented a range of measures that are viable within short and medium-term timeframes. Short-term

strategies are implemented within the year and include approaches that are already used. Medium-term tactics are appropriate for the likely climate changes over the next 20 years and involve making some substantive changes to existing practices. Institutions have been fundamental in the development and utilisation of longer-term measures, and there are few options implemented by farmers in this category. Long-term options often require a more significant investment from farmers. Examples of these measures are visible in Table 5.7.

Table 5.7. *Summary of short-term, medium-term and long-term adaptive measures and responses in Mid-Canterbury*

Type of adaptation	Example of adaptation
Short-term (within the year)	Response to adverse weather events (i.e. moving stock) Monitoring soil moisture and temperature Crop insurance Buying additional feed Reduce stock numbers Changing the timing of activities Modelling Irrigation Grain drier
Medium-term (1-20 years)	Improvements with irrigation efficiencies (Electromagnetic Mapping and variable rate irrigation) Storage ponds Deepen wells on their farms Run-off block (to control their feed) Maintaining their track for stock Winter grazing
Long-term (more than 20 years)	Diversifying income sources Changing crop/pasture species and varieties Planting shelter Stop-banks by the river Power lines underground Wetland restoration Timing of activities Barns for cattle* Aquifer recharge* Move water in different ways*

Note. Adapted from: Research findings

*Indicative of a measure that has not been developed but suggested as options that could be used in the future by farmers within the region

5.4.1. Short-term strategies

All farmers utilised short-term measures. In anticipation of an extreme wind event, farmers would move their irrigators into a safe position and tie them down. Although the wind event did not always occur, D08 said, “you don’t get paid for downtime on irrigators... if you have an irrigator blow over you can’t irrigate for a month”. Farmers were aware of the

economic losses that could occur from not being able to irrigate, and the increased expenses of buying feed in and getting the irrigator fixed. D05 stated he had multiple centre pivots on his farm to provide security if one is damaged in a weather event or breaks down. This farmer had previously lost an irrigator and was aware of how devastating it could be. Crop insurance was also valuable to protect arable farmers' income if crops were damaged from hail storms.

Arable farmers have begun to plant some of their crops earlier because it allows them to spread their water usage over the season. G05 expressed, "we are really stretched if everything needs a lot [of water] at the same time". Planting crops at different times allows an arable farmer to distribute their water usage, and ensures that they are not pressured to apply irrigation to all crops at the same time. This farmer also modelled different wheat varieties to understand how much and when it needs water. G05 could compare the water needs of the wheat crop to the water needs of other crops they were growing and chose varieties that do not require as much water. Early planting exposes crops to late frosts, and this can be adverse for productivity. Sheep farmers also have changed the lambing date of some of their stock, and this is because they have more feed available at the start of the season. They also sell some livestock earlier and receive a better price for this.

Reactive measurements are implemented during an adverse weather event. During extreme rain, farmers would move their stock from paddocks and put them on a concrete pad to minimise damage to a paddock. Dairy farmers would milk once a day and feed out more. If the rainfall was over a prolonged period, farmers would often cull stock if they did not have enough feed, or purchase more feed. Farmers in the high-country were affected by snow, and they used snow groomers in response. They also utilised their natural shelter from hills and trees. G07 noted that they helped their neighbours when the weather turned 'crappy'. However, G07 also said, "we don't do that often because you are normally doing your own [harvest]". Some arable farmers also utilised grain driers so they "can get out and try and get our grass seed in before it blows away".

Farmers are continuously making developments to improve their water and irrigation management. This has included monitoring the soil moisture and temperature to ensure water demands of crops and pastures are met. These improvements reduce water wastage

and save farmers money. G04 stated the reason they have soil moisture probes “was because we pay for power”. D03 explained that probes tell them the percentage of water currently in their soil. Data is sent to the farmer’s phone throughout the day, and the frequency they receive data can be changed. The data provides up-to-date information to the farmer and they can adjust the rate irrigation is applied relative to this. D05 said soil probes allow you to “get greater, brilliant utilisation of the water”. Soil probes also allow farmers to monitor the effects of a rainfall event on the soil moisture. Six dairy farmers and four arable farmers expressed that regularly tracked their soil moisture through this. G07 stated that they had not invested in probes because their soil type is all the same. The sheep farmer on the plains said that they would develop more irrigation if they were able to in the future. However, they acknowledged this might require a change in systems to get a sufficient return on the investment.

Short-term adaptive strategies can be reactive, anticipatory or part of management, and they can reduce vulnerability. The strategies discussed by farmers in Mid-Canterbury were to minimise the adverse effect climate variability has and allowed farmers to continue to be productive and this was critical for their financial return.

5.4.2. Medium-term strategies

Medium-term measures include strategies that can be used for multiple years without additional investment once they have been implemented. As discussed in the short-term strategies, buying feed in is used by farmers in response to an adverse weather event. Some farmers have invested in run-off blocks because it provides them with supplementary pasture and they do not have to buy it from another producer. This has high initial costs, but it is valuable because it enables them to minimise spending and respond to a climatic event. Another strategy that was used each year by dairy farmers was winter grazing with an arable farmer. Generally, farmers use the same grazier each year if it fits in with their management strategy for the year. This minimises the damage done to a dairy farmers’ paddock during winter and diversifies an arable farmers’ income.

Medium-term measures were also implemented to improve water usage. Electromagnetic mapping was used on farms to map the soil characteristics within the soil profile by three farmers including two dairy farmers and two arable farmers. G04 described

electromagnetic mapping as “when they tow a little machine across the paddock, and it reads down to a metre basically, and tells you the soil moisture capacity”. Electromagnetic mapping can help to identify whether variable rate irrigation would be a valuable investment. G04 explained that it was not viable for them to put on variable irrigation as he did not perceive that their soil was variable enough. Two dairy farmers had implemented variable rate irrigation, and this allowed them to adjust the rate irrigation was applied relative to the characteristics of the soil. They would couple this with the monitoring of soil moisture and temperature to improve efficiencies. These farmers also changed the rate around the entry and exit of the paddock, as these were areas the soil would be compacted and need less water. Three dairy farmers also stated they would not apply irrigation to tracks on their farms. A maintained track is beneficial as it minimises the energy cows use walking on it, and this is beneficial during summer and for heat stress. It is also valuable because it reduces the money that needs to be spent on maintaining it.

Farmers who use irrigation stated that they had storage ponds on their farm, or they purchased storage from Lake Coleridge to provide security when there are water restrictions. This includes security for Barhill-Chertsey irrigation users (Trustpower, 2018). Lake Coleridge is indicated on Figure 5.2, the Selwyn District and its proximity to Ashburton is seen in Figure 5.2.

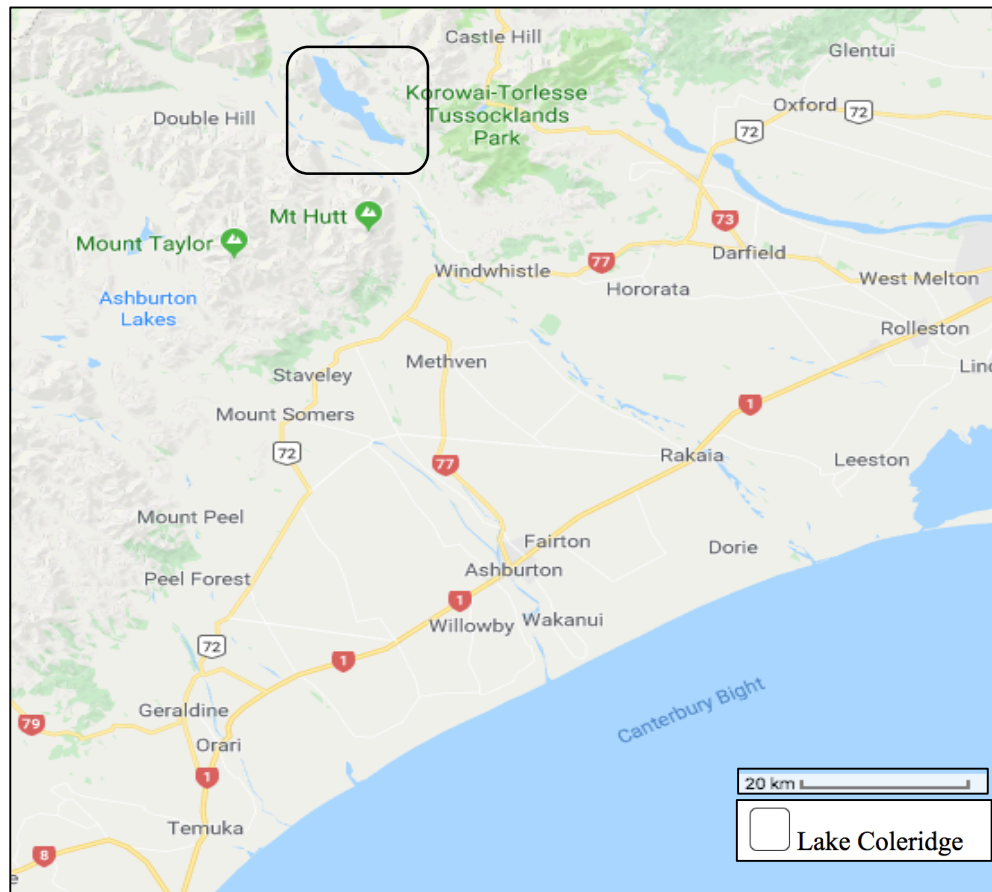


Figure 5.2. Location of Lake Coleridge (Google, 2018)

Arable farmers had less water storage available on their farms than dairy farmers, with some saying they had two weeks, while some dairy farmers had enough for four weeks. Farmers noted that they lined their ponds in some cases to reduce the water lost through infiltration. G01 commented, “it is expensive to do that and take some land out of play”. He also stated it was beneficial to ensure production. Storage ponds are considered a medium-term measure as farmers expressed that it has not been something that they have had to use every year. However, they were also aware that less rainfall could be an issue in the future, and these may not provide the necessary security. Some farmers have deepened their well on their farm to improve water security. Farmers can choose to implement these measures, but also need permission from the council or the organisation responsible. Therefore, these groups also have roles in facilitating adaptation. Medium term measures are considered to provide increased protection for farmers within the next 20 years.

5.4.3. Long-term strategies

Long-term measures require significant investments, and they provide some security into timeframes exceeding 20 years. Long-term measures are implemented by farmers at farm-level or by institutions and organisations at larger-scales. Dairy and arable farmers said that they removed trees when they put in irrigators; many of these farmers reported they tried to retain trees around the edge of their farm. G04 said, “we had 66 paddocks on this farm, and trees around three sides of them, when we put our pivots on we were down to ten paddocks”. There have been increased efforts by four dairy farmers and four arable farmers to invest in shelterbelts on their farms to reduce exposure to winds. These do not provide immediate benefits but will provide shelter in the future. The Foundation of Arable Research have supported this. Trees have other non-climate related benefits including pollination and improving the overall environmental quality. There have been efforts by S02 to restore wetlands, and this helps to improve environmental quality, but was not in response to climatic stimuli.

Arable, sheep and one dairy farmer have diversified their production and income sources. This was because if farmers were adversely affected in one production-system, they would have others to compensate for this loss. It also spreads their income over the year. G01 stated, “We have to, to survive because the cropping commodity prices have been that low, in an ideal world we would probably be all cropping”. Diversification has also included off-farm employment that contributes to the overall economic resources of a farm. Some farmers believed that they think that it is likely Mid-Canterbury will have a shift in production regimes in the future as well. Diversifying is related to the climate, market and financial returns.

Farmers commented that the development of new varieties of seeds and crops could be used in the future, as well as crops that are currently unsuitable for growing in Mid-Canterbury. G05 said, “if the climate is warming, I look at it as an opportunity of what else I can grow”. Farmers were also aware that some crops are more tolerant to drought and wind, and therefore if there were changes to these conditions they could change what was grown. Generally, farmers stated that seed companies would bring to them varieties that were suitable to be produced in the area. Sheep farmers within the district have begun to

trial pasture-legumes on their farms as these grow faster and sheep perform at higher levels.

As well as different varieties, the timing of activities could change. The sheep farmers in the high-country expressed they might be able to lamb earlier. This is likely to be advantageous for them because milder winters will support pasture-growth in this period, and there will be sufficient feed for lambs born earlier. Wintering barns for stock were discussed by D03 as solutions to minimise pugging in winter and as a response to heavy rainfall. One dairy farmer suggested sprinklers in yards could also be used to cool down stock during periods of heat.

The aquifer recharge scheme in Mid-Canterbury is an example of a long-term response to improve water management in the area, and it has been implemented as a trial within the region. Some arable farmers stated that some of the district councillors are opposed to the idea and believe that if it is not developed at a larger scale, “future generations will basically think our generations were criminally negligent to let all that water go to sea when it is such a vital resource”. Dairy and arable farmers were aware of this happening within the district, and it would provide a way to secure water in the future. The sheep farmer on the plains currently uses the stock water system for drinking water for their stock, and therefore, if this scheme was developed at a larger scale they were aware they would have to get consent for a well on their farm for ensured water supply.

Four dairy farmers and two arable farmers suggested that in the future it may be necessary to find new ways to distribute water. This included the suggestion of damming the Ashburton River to provide a reliable water source throughout the year. D05 stated, “if we didn’t have enough water, it might justify the transfer of water from the west coast to the east coast, that is major, and food prices would have to be increasing quite a bit, but who knows”. These measures are not feasible to be implemented or developed by an individual farmer, and they would require district-wide action from organisations and institutions. The long-term measures discussed by dairy farmers were predominantly around water, whereas, arable and sheep farmers were more likely to consider other adaptive strategies that did not involve water.

5.4.4. Summary

Adaptive measures are essential to reduce vulnerability to sources of exposure. In most cases, they are in response to a climatic condition or event, as well as, to ensure productivity and financial returns. It can be hard for farmers to implement adaptive strategies because it is not economically justified. G01 said, “if you are only getting 5% reduction in the risk, is the capital outlay justified? In most cases, it is not”. Many farmers expressed they need to remain productive and economically viable with anything they implement on their farm. This discussion revealed a range of short, medium and long-term strategies that have been or could be used by farmers to reduce exposure and vulnerability. Long-term strategies often require support from organisations and institutions because they are not feasible to develop at a small scale by an individual farmer. Different methods were implemented and considered by farmers relative to their system, the importance of a climatic condition and the environment they worked within. The following section will identify farmers’ perceptions of climate change to understand how they affect adaptive behaviours.

5.5. Perceptions

There is evidence that farmers are aware of the climatic conditions and events that affect their practice and the previous discussion highlights the adaptive measures that they employ. A range of perspectives exist on the issue of ‘climate change’. The media, international leaders and farmers desire to research the topic themselves shapes awareness about climate change. Many farmers expressed they were unaware of where to get reliable information. Three farmers would seek information about longer-term forecasts from NIWA, as well as, other online sources. The perceptions that were evident regarding climate change its causes, the responsibility and need to act will be identified and discussed.

5.5.1. Causation

A range of opinion existed about the contribution of human activities and industrial emissions to climate change. D01 said, “here in Mid-Canterbury we are not causing it... We don’t have any big industrial plants”. In comparison, G03 expressed that humans and

the way resources are used “must be having an effect on the weather”. D07 stated that he is “not convinced that it [greenhouse gases] is the overriding or major reason”.

Various opinions existed when asked about the contribution of dairy farming and livestock to climate change. When asked about agricultural emissions from livestock, G03 responded “I have no doubt that the amount of pollution particularly from dairy cows is significant and causing problems”, in contrast, G07 said, “I don’t agree with a lot that has been said”. S02 stated, “I think we are pretty in the clear with agriculture, as far as emissions go from cattle and that the Serengeti used to have a lot more”. Farmers who had cattle within their practice were less likely to associate them with contributing to climate change. In discussion with D08 about mitigating emissions through reducing the number of cows, he stated that “if we just apply these short-sighted rules we are not going to solve the problem; we are going to hurt the economy”. Other farmers also expressed this. In general, concern was about the economic implications if they were required to reduce the number of cows. D03 said that they had reduced the number of their cows so they could feed them accordingly and this has allowed them to be more productive.

Three farmers in the region talked about the effect irrigation may have had on evapotranspiration and the climate. G03 said, “I believe it is because of the irrigation. I think the fact that the Canterbury plains are all green all the time, we don’t get the heat reflection off the brown paddocks and so therefore, it is putting more moisture in the air”. There was not a relationship between any characteristic of a farmer and understanding the causes of climate change, and there were various perspectives within the district.

5.5.2. Responsibility

There were differences in perspectives about responsibility generally relative to age. D03 expressed “It’s not going to be my generation, it’s going to be my son and grandchild, those are the ones that are going to need to get into it and change it”. In contrast, a younger farmer (D08) with younger children stated, “We have put a fair bit of thought into some of the longer-term stuff, Lead with Pride is probably a good example of that”. The Lead with Pride scheme encourages environmentally appropriate behaviours that will be suitable in the future. Farmers are rewarded for their behaviour with a higher pay-out. No

farmer that supplied to Fonterra discussed a similar initiative. This is a significant example of an organisation facilitating long-term behaviours.

G03 an older arable farmer specified that “I wonder whether New Zealand should be trying to lead the world in climate change alleviation... if we stopped having any effect at all, the world would live for another ten seconds maybe if we are lucky”. The importance of New Zealand’s clean and green image was discussed with multiple farmers. G01 stated that “New Zealand’s problem I see, if we are out there saying how good we are, and we are gradually going down the gurgler in terms of sustainability”. This was one of the only examples of a farmer addressing the reputational issues that may arise for New Zealand. In contrast, G06 stated, “we are pretty clean and green really”. Most people perceived New Zealand as ‘clean and green’ and with a quality environment. Minimal people addressed the reputational issues that may arise relative to New Zealand not acting. Farmers of all ages discussed the longer-term measures that could be implemented by organisations and institutions including the aquifer recharge.

5.5.3. Need to act

All farmers within the region were all aware of the variability of Mid-Canterbury’s climate and that it is not static, “weather is a lottery in Canterbury”. Many farmers stated that the climate has always changed and discussed cyclical patterns they had experienced including 30-year trends of extreme wind and snow. Farmers were generally able to manage this variability and assumed that they would be able to adjust to other changes in climate due to their past experiences and ability to manage variability. G05 expressed, “if the climate changes we will probably just change with it”.

Some farmers also believed the change would be gradual and that “I don’t think we need to panic with climate change”. In comparison to this, S03 said, “there will be significant further implications for this property with climate change. Most of these will impact negatively, but there are also likely to be opportunities presented”. This included milder winters and earlier springs. G05 said, “we can’t do anything about the future...its more reacting to the day-to-day climate than acting to the long-term”. There were various perspectives from different farmers about whether it requires response now or just day to day reactions. However, some farmers did view it as an issue in the future.

An arable farmer commented, “whether you believe in climate change or not, is it natural variability or is it actual climate change, it doesn’t matter, as long as it makes people utilise their resources better”. There was no variation based on specific characteristics of farmers, and variation also existed within farm system groups. Generally, arable and sheep farmers who were more reliant on the climate and using resources more efficiently were more aware of the long-term measures that were available and were looking at the implementation of medium and long-term solutions rather than just short-term. All farmers that used irrigation considered alternatives for water storage and distribution.

5.5.4. Summary

Various opinions existed about climate change, causation, responsibility and the need to act. These are important to consider because if people do not see it is urgent or a pressing issue, they are less likely to respond. Alongside this, climate change is viewed as a distant challenge rather than requiring an immediate response. The need to adapt generally varied by age, and those more reliant on climate for their practice were more concerned.

5.6. Conclusion

Within Mid-Canterbury there is a range of farmers and farms with various characteristics operating within different physical and environmental settings. Climatic events and conditions shape the exposure-sensitivity and vulnerability of farmers. The most important factors are water, temperature and the experience of extreme events; these can impact productivity and financial return. Climate change in the future will likely exacerbate the existing challenges, and create new challenges and opportunities. Vulnerability is also shaped by the market, financial and institutional forces. These factors influence what farmers can do and their financial resources.

To minimise vulnerability, farmers implement and utilise adaptive measures. These can be reactive, anticipatory or part of on-going management and provide short, medium and long-term strategies that can mitigate the possible impact. The utilisation of these methods is rarely purely in response to climatic stimuli; they are also to ensure productivity is not affected, and therefore, their financial return is maintained. Farmers generally utilised short and medium-term measures on their farms, and many of the long-term solutions

require support from organisations and institutions including industry-led groups, milk companies and district and regional councils. These organisations will be fundamental in the development and utilisation of adaptive measures that provide security for farmers beyond 20 years.

Farmers also hold a variety of opinions about the causes of climate change, whose responsibility it is and the urgency to act. These are important to consider because they influence the utilisation of adaptive measures. The need to act in response to climate change was generally perceived as more important for younger people versus older people. There was also a difference between Synlait and Fonterra suppliers, with Synlait farmers being encouraged to think long-term and being rewarded for this. Synlait markets itself as being environmentally and socially sustainable. In comparison, no Fonterra farmers reported being part of an initiative that shaped their behaviours long-term. Perspectives regarding the urgency to act were variable and did not correlate to any specific characteristics of a farmer. However, those reliant on the climate were generally more concerned.

The following chapter will discuss the implications of these findings. It will provide a discussion of the main actors in adaptation, as well as, possible ways to facilitate long-term adaptation and relationships between different actors.

Chapter Six: Facilitating adaptation in the agricultural sector

“New Zealand’s challenge and opportunity is to transform our economy so it works with the planet, not against it”

- Hon James Shaw, Minister of Climate Change

6.0. Introduction

This research has aimed to understand how climate change will affect agricultural producers in Mid-Canterbury. The results presented in Chapter Five provided an understanding of the climatic sources of exposure, the context farmers operate within, adaptive measures used and perceptions of climate change. The results also demonstrated that various actors implement adaptive strategies, and dependent on the approach there might be multiple actors involved. It was also highlighted that perceptions of climate change impacts influence the adoption of adaptive strategies by farmers. This chapter considers how adaptation can be facilitated. It will provide a discussion of how different actors engage with adaptation including farmers, suppliers, industry groups, and the central and local government authorities. Within the central and local authority discussion, the global context will also be introduced. Finally, it will examine how suppliers and industry groups can act as boundary groups and facilitate adaptation, improve awareness and enhance relationships between farmers and the government. Adaptation is fundamental to managing the effects of climate change, and thus it is essential to understand the current approach of different individuals, groups and agencies.

6.1. Farmers

Farmers within Mid-Canterbury readily used short and medium-term adaptive strategies that were reactive, anticipatory or part of on-going management. Most measures were undertaken to ensure that a climatic event or condition did not compromise their productivity or profits. Other studies have also found that adaptive strategies are implemented in response to multiple sources of exposure (Reilly & Schimmelpfennig, 1999; Niles et al., 2015; Cradock-Henry, 2017). This discussion will emphasise the relationship between the climate and the market and the risk of maladaptation if there is not integration between short and long-term measures. The influence of perception upon the use of adaptive measures is also examined.

6.1.1. Climate and the market

The climate and market were the two most important sources of exposure for farmers in Mid-Canterbury. The market and climate are inherently related; the market is shaped by climatic events and conditions which may increase or reduce the demand for certain goods (Adger & Brown, 2009; Pelling, 2010; Linnenluecke, Griffiths, & Winn, 2013). For example, a drought can reduce production, decreasing the supply of goods available, and as a result the price goods can increase (Oxley, 2012; Nelson et al., 2014). Consumers often shift their behaviours in response to these market shocks and reduce their spending on expensive products; however, this can provide farmers with benefits if they can fill the supply gap and receive a greater return (Oxley, 2012; Nelson et al., 2014). Farmers have minimal ability to control market conditions because these do not originate on the farm, but they can try to respond to changes in market conditions. Diversifying income sources and selling stock at different times of the year were adaptive measures that were used by farmers to minimise the effects of low market prices. The market also influences the ability to engage in adaptive behaviours, notably those that require financial capital. This is because it affects the economic resources a farmer has, and this is one determinant of adaptive capacity (Smit & Wandel, 2006).

Consumers and non-governmental organisations are demanding sustainable business practices, and some adaptive measures also help to improve sustainability, such as the planting of trees and improved water use efficiencies (Smith & Olesen, 2010). These practices recognise that previous behaviours are not necessarily going to be viable in the future (Wells, 2013). Sustainable business practices integrate social, economic and environmental dimensions, and seek to increase the value of these. Thus, they include measures that aim to minimise or eliminate negative environmental impacts, such as improving the use of water through the utilisation of soil moisture probes and efficient irrigation infrastructure (Wells, 2013; Kopina & Blewitt, 2014). Through adopting sustainable business practices, the needs of consumers can be met (Wells, 2013). Adapting can provide indirect means to improve farmers' accessibility to the market, capitalise on new opportunities and reduce exposure (Anderson, 2010; Parliamentary Commissioner for the Environment, 2016a).

6.1.2. Maladaptation

Farmers within Mid-Canterbury use many short-term adaptive measures when approaching climate change. Smithers and Smit (1997) and Magnan et al. (2016) identified that short-term strategies in response to climate variability may not be well suited for the projected changes in climate, and may increase vulnerability; this is maladaptation. Maladaptation describes an action that may result in undesired and unintended consequences (Rickards & Howden, 2012; Magnan et al., 2016). Christian-Smith, Levy, and Gleick (2014) examined the response to drought in California between 2007 and 2009. The actions taken in response to the drought included the increased use of groundwater resources, and the transfer of water takes amongst private landholders. Corresponding to this period, Famigliette et al. (2011) found that between 2006 and 2010 groundwater levels within the San Joaquin Basin in California declined by two to six feet. Without adequate recharge water may not be able to be used in the same way in the future.

Mid-Canterbury may face similar issues to California in the future. Groundwater is used within Mid-Canterbury for irrigation. However, groundwater in the area is over-allocated, and under climate change projections it is likely that irrigation reliability will reduce in the future. This will have implications for productivity and economic returns of producers in the area (Ashburton Zone Committee, 2011; Bright et al., 2011). Therefore, short-term and long-term timeframes must be considered simultaneously to ensure the risk of maladaptation is minimised. Adger et al. (2005) noted that investment in irrigation must consider long-term changes to ensure the investment can generate benefits. Within Mid-Canterbury, there are many ideas for the development of large-scale storage ponds including the Klondyke Proposal (Rangitata Diversion Race Management Limited, 2018). This would provide an option to improve water reliability in the future, relative to climate change. The Rangitata Diversion Race Management Limited developed this project, highlighting that organisations may be influential in minimising the risks of maladaptation. Alongside this, farmers had limited understanding of what would constitute a significant change in climate. Therefore, organisations may be essential to support the development of long-term measures and reduce the risk of maladaptation.

In contrast to this, short-term adaptive measures in some situations can enhance the capacity to deal with long-term changes (Howden, Crimp, & Nelson, 2010; Reidsma,

Ewert, Lansink, & Leemans, 2010). Howden et al. (2010) found that in Australia many of the short-term adaptive responses currently used will be suitable for the projected changes in climate. Marshall (2010) identified that the adoption of technological measures and use of climate forecasts by graziers could help them become better prepared for the future. This highlights that there can be synergies between short-term and long-term adaptive measures.

6.1.3. Perceptions

The way people process and interpret information affects awareness and perceptions about climate change (Whitmarsh, 2011). Awareness of climate change is shaped by where farmers get information from, including the media, political leaders, and their social, industry and professional networks (Weber & Stern, 2011). It is valuable to consider the quality and accuracy of these information sources. Scientists can provide reliable information to the public, however it is not necessarily accessible or understandable (Moser, 2009). In comparison, the media is readily accessible but does not necessarily interpret the observed changes in climate or weather events as accurately (Moser, 2009; Whitmarsh, 2011). For example, some media outlets have portrayed mild summers or warm winters as being contrary to climate projections, and this fails to consider the bigger picture of climate change (Whitmarsh, 2011). Industry groups can also convey information about climate change; however, there can be biases in the way the information is presented. Depending on the source there can be the provision of conflicting and often incorrect information to farmers.

Farmers were aware that climate change would exacerbate the current challenges faced, and some farmers identified that they may experience new climatic challenges and opportunities. The identification of these impacts was a motivator for action. In contrast, an understanding of climate change and the causes did not influence adaptive behaviours. This is consistent with Arbuckle et al. (2013) and Niles et al. (2016). These studies found that opinions about the causes of climate change were not a strong predictor of support for adaptive action. In comparison, the identification and realisation of possible impacts had a more significant influence on adaptive behaviours. Therefore, providing better quality information including that about the consequences of climate change may help to improve understanding and facilitate the adoption of long-term adaptive measures.

6.1.4. Summary

Farmers predominantly utilise short-term adaptive measures. There is a risk that maladaptation could occur if short-term measures are not suitable for future changes in climate. Due to farmers having limited awareness surrounding what constitutes significant changes in climate, it can be difficult to facilitate the adoption of adaptive methods that will be suitable in the next 30 years. Therefore, more information and other organisations may be required to facilitate adaptation.

6.2. Industry groups and suppliers

In Mid-Canterbury, farmers, as elsewhere, interact with industry groups and suppliers. Smit and Skinner (2002) identified that these organisations can inform ‘best management practices’ on farms, and can influence farmers’ behaviours. This means they may be able to encourage the use of adaptive measures (Smit & Skinner, 2002; Reid, Smit, Caldwell, & Belliveau, 2007; Linnenluecke et al., 2013; Bryant et al., 2016). Best management practices are also informed by identifying consumer demands and tailoring practices to align with these, such as the use of sustainable business practices (Haugh & Talwar, 2010). Recently, in the Climate Change Adaptation Technical Working Group (2017) review of adaptation in New Zealand, it was recognised that industry bodies have a critical role in adaptation. The Climate Change Adaptation Technical Working Group is comprised of experts and was created to help New Zealand become better prepared for climate change. Their purpose is to provide advice to the Minister of Climate Change, with the aim of improving the ability to respond to climate change as well as sustainably growing our economy. The following discussion will consider the role of different organisations in shaping adaptive behaviours.

6.2.1. Industry groups

Within Mid-Canterbury farmers have relationships with the Foundation of Arable Research, DairyNZ and Beef and Lamb. These organisations host field days that farmers are invited to attend. Field days provide farmers with opportunities to learn about new technologies, practices and tools which they can use within their farming practice to improve performance. These provides opportunities to exchange information, develop

relationships with farmers and enhance social capital (Adger, 2003; Petzold, 2016). Adger (2003) describes social capital as “relationships of trust, reciprocity, and exchange” that allow people to improve risk management and act collectively (p. 389). Adger (2003) differentiates between ‘bonding’ and ‘networking’ social capital. Bonding includes relationships and knowledge sharing between friends and families. Networking refers to links outside one’s community and tends to rely on legal and formal institutions; industry groups and farmers would be an example of this. Social capital is valuable because it is a determinant of adaptive capacity (Smit & Pilifosova, 2001). Industry groups can provide financial support for farmers to implement specific initiatives on their farm. An example of this is the ‘Trees for Bees NZ’ research initiative that was partially funded by the Foundation of Arable Research (Foundation Arable Research, 2014). Although this was not directly related to climate change, it provided an opportunity to improve the environmental quality of the farm that was part of this project and trees also provide shelter which can act as an adaptive measure.

These organisations also provide connections between Environment Canterbury and farmers. They assist farmers in complying with the regional council’s rules and regulations. Each organisation has an Environment Canterbury approved Farm Environment Plan template, and farmers can seek advice from the industry group when completing this (Environment Canterbury, 2018b). They also provide submissions on publicly notified resource consent applications and plans that may have implications for farmers within their network, such as the National Policy Statement for Freshwater Resources which DairyNZ and Beef and Lamb made submissions on (Ministry for the Environment, 2014). One of the objectives of the National Policy Statement is “to avoid any further over-allocation of freshwater,” and this has implications for the management of freshwater resources by regional councils (Ministry for the Environment, 2017c, p. 15). This can affect the how farmers can use water in Mid-Canterbury, especially because the zone is over-allocated. This provides a way to represent farmers’ interests, with industry groups acting as a mediator between local authorities and farmers.

Climate change mitigation has been a primary focus of Beef and Lamb and DairyNZ (DairyNZ, 2017a; Beef and Lamb New Zealand, 2018). This is likely because the conversation around livestock emissions is very politicised and polarising. Both these

organisations are members of the Biological Emissions Reference Group. This group aims to create information that can be used to develop policy and support New Zealand's greenhouse gas reduction obligations. Some mitigative measures can provide indirect options for adaptation through educating farmers about climate change and encouraging the sustainable use of resources (DairyNZ, 2016; Beef and Lamb New Zealand, 2018). It was identified by Berkhout, Hertin, and Gann (2006) that many organisations do not necessarily directly consider climate change adaptation, and instead indirectly assist in adaptation which is consistent with DairyNZ and Beef and Lamb.

In comparison to this, the Foundation of Arable Research focuses on adaptation. They have been one organisation involved in developing tools for 'Resilient Cropping' and as described by the Foundation of Arable Research, "resilience is the ability to cope with adverse events" (Foundation Arable Research, 2018). Adverse events include extreme weather events, fuel cost spikes and restricted access to water. As part of resilient cropping, a 'Canterbury long-term Climate Change impacts' information sheet was developed. This includes the identification of possible impacts and suggests adaptive measures, including planting seeds earlier, changing the varieties grown, and the adoption of technological innovations. The Foundation of Arable Research's concern with adaptation is different to the approach of DairyNZ and Beef and Lamb.

Organisations can motivate behaviour shifts, and Reid et al. (2007) emphasised that organisations could be fundamental in shaping behaviours indirectly. These organisations provide evidence that climate change is on their agenda. Industry groups have developed relationships with both farmers and local and central authorities. Therefore, these groups have the potential to play a significant role in facilitating the implementation of adaptive measures by farmers.

6.2.2. Suppliers

Although all farmers expressed they had some degree of interaction with their suppliers; Synlait dairy farmers, in particular, discussed how their behaviour was influenced by their supplier. The Synlait 'Lead with Pride' initiative has helped Synlait achieve 'dairy farming excellence' through complying with environmental, animal health and welfare, milk

quality and social responsibility rules and regulations (Synlait, 2013b). Synlait has approximately 198 suppliers from Temuka to Culverden, of which, at least 50 are gold-plus or gold-elite suppliers. An environmental advisor from Synlait informed me that Synlait works closely with their suppliers to help them improve their practice (E. Brand, personal communication, 29 January 2018). The criteria relating to different supply levels are visible in Table 5.1. Gold-elite farmers are required to comply with the gold-plus requirements and additional requirements. Examples of environmental regulations that must be complied with are shown in Table 5.2.

Table 6.1. *Different Synlait supply levels*

Gold	Gold-plus	Gold-elite
Known as good practice this is the standard that is currently being met by all Synlait milk suppliers. There is no ISO 65 certification or premium payment paid for milk at this level.	Known as best practice Gold Plus has additional standards above 'Gold' that must be met. These requirements cover the four pillars. Suppliers are ISO 65 certified and premium payments are paid for their milk up to a value of \$0.06/kgMS.	Known as leading practice when Gold Plus certification has been maintained for a minimum of 12 months only then can Gold Elite certification be obtained with additional requirements in all four pillars. Suppliers are ISO 65 certified and higher premium payments are paid for their milk up to the value \$0.12/kgMS.

Note. Adapted from: Synlait (2013a)

Table 6.2. *Examples of gold-plus and gold-elite requirements farmers must comply with*

	Gold-plus	Gold-elite
Irrigation	Resource consent/water supply agreement requirement met and understood by relevant staff. Monitoring reports required. An in-use irrigation and Water Operation Manual that includes system operation and maintenance, and that is understood by all relevant staff (including training, maintenance and records)	For systems installed pre-October 2013 an Irrigation New Zealand evaluation to be carried out and upgrades undertaken as soon as possible. Evaluation to be repeated every five years thereafter.
Soil moisture	Soil moisture monitoring (with records) handheld probes, or monitoring devices that are shared between adjoining farms are acceptable	On farm soil moisture monitoring for all known soil types required

Note. From the Lead with Pride Handbook provided by E. Brand, personal communication, 29 January 2018

The farmers within Mid-Canterbury who supplied Synlait all used soil moisture probes on their farms, and this is reflective of the requirements set by Synlait as seen in Table 5.2. This improves water efficiencies and water use, and is an example of an adaptive measure. Synlait's requirements show the influence suppliers can have on farmers' behaviour. Farms are audited each year by AsureQuality Limited to ensure that they are complying with the initiative. Audits are completed at different times each year and can include all components or one-third of requirements (E. Brand, personal communication, 29 January 2018).

Other examples of environmental policies include measures around water use, effluent management, nutrients and energy. Synlait stated their environmental policies are designed to maintaining the environment for future generations; this approach recognises the significance of the environment in the future (Synlait, 2016)(Synlait, 2013a) Alongside this, the inclusion the environmental focus is expected to have a positive impact on businesses and profitability (E. Brand, personal communication, 29 January 2018). As a result, farmers receive a premium pay-out for their product. Kenny (2011) emphasised the need for sustainability role models to encourage long-term resilience. Synlait provides an example of this as they seek to lead from the front. It is also valuable to note that Synlait suppliers expressed a high level of awareness around long-term behaviours and were aware of the implications of climate change.

Synlait has begun to talk about climate change and greenhouse gases with their producers in their monthly newsletter which all suppliers receive. Synlait have also begun to consider making the incorporation of emission reduction management plans a requirement for gold-plus and gold-elite suppliers (E. Brand, personal communication, 29 January 2018). If this is implemented, it could indirectly aid adaptation. This is also driven by consumer demands and their concern and interest around climate change greenhouse gases and mitigation.

Synlait, Fonterra and the Foundation of Arable Research have Environment Canterbury approved Farm Environment Plans, and help farmers to abide by the rules set by Environment Canterbury, as well as developing relationships between different farmers, themselves and local authorities (Environment Canterbury, 2018b). Therefore, these

organisations also offer linkages between the regional authority and farmers. It is likely other companies are also influential in shaping behaviours and provide linkages, but Synlait was discussed by farmers as being notably significant.

6.2.3. Summary

Industry groups and suppliers can influence farmers' behaviours. They are also able to help farmers comply with the regulations set by the regional council. Industry groups can represent farmers' interests and facilitate the development of policy. However, most of the work on climate change indirectly focuses on adaptation.

6.3. Governance

New Zealand has participated in international climate change negotiations. These have included the ratification of the United Nations Framework Convention on Climate Change (1992), Kyoto Protocol (1997), and The Paris Agreement (2015). These agreements encourage countries to act on climate change, influencing the approach taken by the central government. The Paris Agreement (2015) aims to limit the rise in global average temperatures “to well below 2°C above pre-industrial levels” and to increase “the ability to adapt to the adverse impacts of climate change and foster climate change resilience” (p. 3). As New Zealand has ratified this agreement, the nation has a responsibility to assist in climate change mitigation and adaptation.

In New Zealand, the central, regional and local government all have a role in climate change adaptation (Measham et al., 2011; Reisinger, Wratt, Allan, & Larsen, 2011; Bryant et al., 2016). Climate change adaptation was initially approach from the national level. The Energy and Climate Change Amendment to the Resource Management Act in 2004 altered this and directed responsibility to local-level governments (Greenaway & Carswell, 2009). Under this amendment, local authorities are required “(i) to plan for the effects of climate change; but (ii) not to consider the effects on climate change of discharges into air of greenhouse gases”. In other words, they can coordinate adaptation. The transfer of responsibility occurred because local governments were perceived to be more equipped to manage risks in their area (Greenaway & Carswell, 2009). This recognises that each region and district will face unique challenges., however, a nation-wide approach to adaptation

may help to mainstream adaptation and inform the role of local authorities. The current approach to adaptation by central and local authorities will be examined in this discussion.

6.3.1. Central government

The central government creates legislation and policy frameworks, provides information and guidance to local authorities, funds research, and prepares for and responds to hazard events including those resulting from climate change. Policies include those related to infrastructure, such as irrigation developments, and freshwater resources (Ministry for the Environment, 2014). Irrigation investment is valuable as it strengthens the ability of farmers to manage dry conditions, however, if it is not incorporated appropriately there is the risk of maladaptation, as discussed earlier in this chapter. The Climate Change Adaptation Technical Working Group (2017) identified that within different government agencies there are different opinions about adaptation, which means there are not clear or consistent goals. Various approaches have been taken by different agencies towards climate change adaptation; some have made positive and proactive steps, whilst others risk exacerbating New Zealand's vulnerability. In most cases, the central government approach has been reactive to climate-related events. The findings of the Climate Change Adaptation Technical Working Group (2017) were based on the approach of the previous government and were accurate as at May 2017; therefore, it is important to consider the approach of the new government.

The New Zealand Labour and New Zealand First coalition, with confidence support from the Green Party, consider climate change as a higher priority than the previous government, with climate change featuring in their first 100-days plan. The 'Speech from the Throne' stated that, "climate change is the greatest challenge facing the world", and "this ambitious plan to take real action on climate change will involve all New Zealanders" (Arden, 2017). In this speech, it was stated that existing Crown investments for irrigation would be honoured, but support would not grow (Arden, 2017). Furthermore, the Minister of Climate Change, Hon James Shaw attended the United Nation's COP23 conference in Germany in November 2017 and delivered New Zealand's new approach on an international stage. This includes the development of an independent Climate Commission, green investment fund, further investments in renewable energy, an increase in the number

of trees, and the continuation of research in emissions reduction, notably for the agricultural sector (Shaw, 2017a).

Although the new government considers climate change as a more significant issue than the previous government, their approach is very focused on mitigation. Mitigation will still be beneficial if it includes options that also act as adaptive measures. Upon the release of the report by the Climate Change Adaptation Technical Working Group (2017), the Minister of Climate Change reported that it is essential New Zealanders have a clear picture of the potential impacts so that people and groups can make well-informed decisions on how to adapt and respond (Shaw, 2017b). Therefore, there is a possibility that some additional direction will be given surrounding adaptation within this government's term.

6.3.2. Local authorities

Local authorities are instructed by the central government to use the available legislation, policy and guidelines, respond to climate change impacts and consider climate change in planning. The Resource Management Act (1991) states that authorities are to have “particular regard to the effects of climate change” (p. 63). It also instructs local authorities to consider the needs of their communities and citizens in planning and decision-making. Therefore, under the Resource Management Act, councils are required to prepare communities for and manage the risks of climate change. The ‘Climate Change effects and impacts assessment: a guidance manual for local government’ and ‘Coastal hazards and climate change guidance for local government’ were prepared by the Ministry of Environment in 2008 and 2017 respectively. These documents provide information about the potential impacts of climate change, and guidance about adaptive measures that could be used (Ministry for the Environment, 2008, 2017a). Therefore, the utilisation of adaptive measures is at the discretion of each council, and thus, there are variations in approach relative to how climate change and the need to adapt is perceived.

The Climate Change Adaptation Technical Working Group (2017) identified barriers for local authorities to engage in climate change adaptation. This included a lack of information, resource constraints, limited leadership, and lack of guidance from the central government, and limited community buy-in. Other barriers identified by Measham et al.

(2011) included a limited understanding of the available information and the belief there were more pressing issues. Limited community buy-in is significant and is partially related to how climate change is perceived within the community. This research identified that farmers were sceptical about the causes of climate change, and many saw that there were more pressing issues. Therefore, these attitudes may influence the response taken in Mid-Canterbury by the local authority.

The Ashburton District Council is the territorial authority for Mid-Canterbury. The Ashburton District Council's Long Term Plan (2015-25) recognises that the design and construction standards of infrastructure need to withstand natural hazards and changes in climate (Ashburton District Council, 2015). The significant forecasting assumptions used in the development of this plan included the consideration of climate change. It was stated that "Council has assumed there will be some impacts arising from climate change over the long term but as these impacts are not yet clearly identifiable, they have not been explicitly incorporated into general planning decisions" (Ashburton District Council, 2015, Part 7, p. 11). There is minimal action being taken in response to climate change and its potential impacts.

The Local Government Leaders' Climate Change Declaration was created in 2015 as it was recognised by Mayors and Chairs in New Zealand that a holistic approach to climate change was necessary. The declaration seeks to encourage the central government to improve their approach to climate change mitigation and adaptation, and work with communities to help them understand, prepare for and respond to the potential impacts of climate change. It also identifies that long-term thinking and policies are necessary (Local Government New Zealand, 2017). It also recognises that collaboration with and between central and local levels of government are required. In July 2017, the Ashburton District Councillors decided not to sign the declaration, in a decision of four votes for the motion and nine against (Ashburton District Council, 2017). In communication with an Ashburton District Council staff member that attended the meeting it was revealed that councillors opposed to signing the declaration believed that it was too focused on rural areas rather than having a holistic approach considering urban issues as well, and they believed that Ashburton was doing a lot of positive environmental work, such as that around water quality. In contrast, other councillors believed that the declaration should have been signed

because it was important for advocacy (P. Clark, personal communication, 31 January 2018). There were various perspectives regarding the declaration within Mid-Canterbury, and this made it difficult to facilitate adaptation.

Approximately 54 regional, district and city authorities have signed the declaration, and 24 have not. Other councils that have not signed the agreement include the Hurunui District Council, Timaru District Council, Mackenzie District Council, Manawatu District Council, Whangarei District Council and Westland District Council. Many of the areas that have not signed the declaration are rural areas. By contrast, most city and regional authorities have signed the agreement. Fulton (2008) as cited in Reisinger et al. (2011), found that within some rural communities, and their councils, scepticism and uncertainty surrounding climate change is common. This may relate to why these districts have not signed the declaration. Measham et al. (2011) found that how leaders perceived climate change within three councils influenced the adoption of adaptive measures. It was also perceived by many that local governments have more pressing issues and it can be hard to justify the allocation of resources to climate change. Finally, Measham et al. (2011) found that the information available to councils is not understandable or communicated effectively. Therefore, the devolution to local-level faces some challenges, and perspectives within the government influence the actions taken.

In contrast to the Ashburton District Council, Environment Canterbury, the regional authority, has signed the local government declaration (Local Government New Zealand, 2017). Environment Canterbury is responsible for the management of natural and physical resources within the district, therefore, it is important that they recognise that climate change adaptation is fundamental within their policies (Environment Canterbury, 2015). Management of natural resources includes improving water efficiency, knowledge of natural resources, potential impacts on coastal communities and preparedness for more extreme and volatile conditions including storms; this recognises climate change. In Environment Canterbury's Long-Term Plan (2015-2025) it is stated within the 30-year infrastructure section that the probable future scenario is: "climate change bringing greater frequency and intensity of storms and sea level rise; however, changes within the 30-year planning horizon will be modest" (p. 13). The plan also identifies that storms will become more severe. Most of the recognition towards climate change adaptation of local

governments consider infrastructure, and this is because it is within their jurisdiction as designated in the Resource Management Act (1991). However, the effects of climate change will not only be related to infrastructure, and therefore, there may be a need for the central government to provide further guidance to authorities to ensure further effects are considered.

6.3.3. Summary

Both central and local authorities have roles in facilitating climate change adaptation. There is currently limited integration between the different levels of government, and there is limited guidance. Therefore, the approach to adaptation appears to be relatively fragmented and may be somewhat dependent on those within the council. To eliminate this issue, adaptation needs to be mainstreamed.

6.4. Facilitating adaptation and boundary/intermediary organisations

The previous discussion highlighted that farmers, suppliers, organisations and each level of the government have different roles and capabilities in climate change adaptation. In general, there is limited integration between farmers and the different levels of government. In contrast, Chapter Five and the discussion above identified that organisations and suppliers can be influential in shaping the behaviours of farmers, and can also help farmers achieve the regulations set by regional councils. They also provide opportunities for farmers' voice to be represented and influence policies that would directly affect them. In the past it has been perceived that 'better' and 'more' information is needed to encourage the adoption of adaptive measures (Tribbia & Moser, 2008). However, more information does not necessarily motivate action. The opportunity that exists for suppliers and industry groups to act as 'boundary' organisations to facilitate adaptation will be discussed. The concept of boundary organisations will be introduced and how they can facilitate adaptation, improve awareness and build relationships.

6.4.1. Boundary organisations

The concept of a boundary organisation was introduced by Guston and drew on principal-agent theory. Guston (2001, p. 401) identified that boundary organisations seek to meet three criteria:

- (1) They provide the opportunity and sometimes the incentives for the creation and use of boundary objects and standardised packages. This includes policy advice, research and assessments.
- (2) They involve the participation of actors from both sides of the boundary, as well as professionals who serve a mediating role
- (3) They exist at the frontier of the two relatively social worlds of politics and science, but they have distinct lines of accountability to each.

Boundary organisations are critiqued because the theoretical considerations behind the concept are too static and these divide science and policy into two very separate domains (Miller, 2001). It also neglects the fact that there could be multiple boundaries that are important (Cash et al., 2003). Despite this, it provides a valuable framework to consider how organisations can facilitate adaptation as they offer opportunities to create meaningful links between different groups of people (Guston, 2001). Boundary organisations are characterised as disseminating knowledge, supporting capacity building and engaging more participants in the adaptation planning process (Bauer & Steurer, 2014). Therefore, they act to facilitate adaptation. This discussion will consider the potential of industry groups and suppliers to act as boundary organisations which facilitate adaptation, improve awareness and build relationships. Therefore, it is important to note that the concept has been used slightly differently to the three criteria listed above, as the two distinct worlds are considered as practice rather than policy in this example.

6.4.2. Facilitating adaptation

Boundary organisations can connect practice, science and policy; the disconnect between these have previously been a barrier to environmental planning decisions (Tribbia & Moser, 2008; Hoppe & Wesselink, 2014). As seen in Figure 6.1, the relationship between boundary organisations and farmers and government is identified. The boundary

organisation in this context is situated between the farmers and the different levels of government. This creates a link between the two different sides of the boundary.

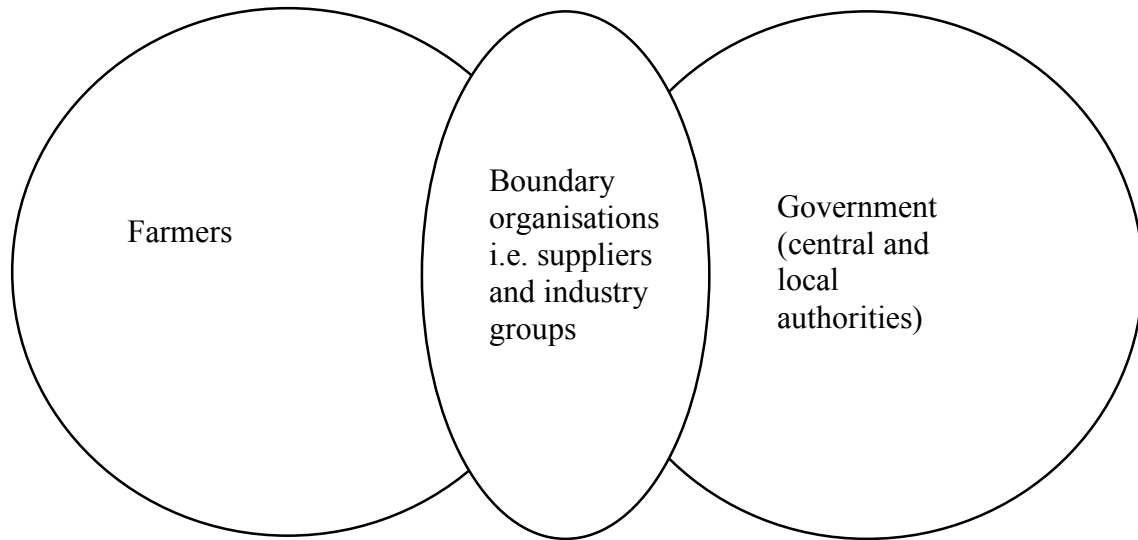


Figure 6.1. Simplified characterisation of boundary organisations (in the context of this study). Adapted from: Hoppe, Wesselink, and Cairns (2013)

An example of this within Mid-Canterbury is the creation of Environment Canterbury approved Farm Environment Plan templates by DairyNZ, Fonterra, Synlait, Foundation of Arable Research and Beef and Lamb. These organisations provide support to both the regional council and farmers to support them in achieving good management practices, which can indirectly support climate change adaptation. Boundary organisations require participation from actors on both sides of the boundary, and they share and transfer knowledge between the parties on each side of the boundary (Guston, 2001; Dannevig & Aall, 2015).

Boundary organisations can create ‘boundary objects’ which include policy advice, scientific information and assessments to multiple audiences. (Corfee-Morlot, Cochran, Hallegatee, & Teasdale, 2011). Cash (2001) found that boundary organisations promoted the successful transfer of and use of scientific information in water management in the High Plains of the United States of America. A similar example is visible within Mid-Canterbury, where industry groups and suppliers have supported farmers to improve their water use efficiencies as aligned with institutional requirements. The transfer of

information and learning opportunities helps build social capital, thus enhancing adaptation (Adger, 2003).

6.4.3. Improving awareness

Boundary organisations can distribute information to farmers to improve their understanding of climate change as well as informing farmers about their available options so that they are more aware and know how to deal with them (Carr & Wilkinson, 2005; Corfee-Morlot et al., 2011). This is important because if farmers were aware of the magnitude of changes that are likely with climate change, they would be more likely to engage in different and longer-term adaptive behaviours. The provision of information on climate change by Synlait to farmers is an example of a supplier seeking to improve awareness about climate change (E. Brand, personal communication, 29 January 2018).

Farm discussion groups, such as those hosted by DairyNZ and the Foundation of Arable Research, provided farmers opportunities to learn new ways of knowing and doing (Carr & Wilkinson, 2005). Farmers in Mid-Canterbury had mixed opinions about these with some stating they were valuable, while others avoided them. These can give farmers information about available adaptive measures, and how these can be used. The transfer of knowledge between farmers and organisations can also help to prevent maladaptation (Pelling, 2010). This is significant, as there is the possibility that maladaptation could occur if short-term and long-term options are not planned within an integrated framework. Therefore, boundary organisations can provide information on climate change which is critical in communities where it is not necessarily perceived as a threat (Phadke, Manning, & Burlager, 2015).

6.4.4. Building relationships

Boundary relations can facilitate the creation of useful information. This can be used to inform governments of the current attitudes towards adaptation, and what is being done in the field (Tribbia & Moser, 2008). This may be able to influence policy and ensure farmers interests are represented and understood. In turn, boundary organisations also provide an opportunity to deliver the interests of the central government and local authorities, to support them in the development of policies, and to ensure farmers are complying with

rules and regulations. DairyNZ and Beef and Lamb are both part of the Biological Emissions Reference Group, which seeks to inform the government about biological emissions and inform the development of policy. However, DairyNZ and Beef and Lamb are also important in recognising that there is a need for climate change mitigation and informing farmers about this.

In order to build valuable relationships that help to enhance social capital, trust must exist between the different actors (Tribbia & Moser, 2008). In a case study in Metro Vancouver, boundary organisations were successful when the public perceived them as credible, honest, and legitimate, and when they provided action-orientated support (Bauer & Steurer, 2014). Therefore, the development of the relationship between the different levels of government and farmers is reliant on a relationship between suppliers, industry groups and government, and farmers, suppliers and industry groups. In Mid-Canterbury, as seen in Chapter Five not all farmers wanted to engage with these organisations; therefore, building trust will be essential for the success of these organisations.

6.4.5. Summary

Industry groups and suppliers can act as ‘boundary’ or ‘intermediary’ organisations and help to facilitate adaptation, improve awareness and help to develop relationships between the main actors in adaptation. This is significant, as many of these groups are already developing relationships with and informing the behaviour of farmers within Mid-Canterbury. This provides an opportunity to facilitate adaptation. Although, the current approach of these organisations, as discussed earlier in this chapter, does not necessarily directly consider adaptation, it is likely that as adaptation becomes more mainstreamed there will be a greater need for boundary organisations, and industry groups and suppliers can act as these organisations.

6.5. Conclusion

Farmers, suppliers, industry groups, local and central government authorities all have a role in facilitating adaptation. Each organisation has a different capacity within which to do this. Farmers readily utilise short-term strategies on their farm, and the use of adaptive measures is dependent on how they perceive climate change as a risk. Short-term options

can be problematic as they may encourage maladaptation if there is not integrated planning between the development of short-term and long-term options. Suppliers and industry groups have been shown to influence behaviours. They create linkages between farmers and the different levels of government as well. At each level of the government (central, regional and local authorities) there are various approaches to adaptation. The approach of local authorities can be limited by community-buy in, perspectives of decision makers and the lack of direction. There is generally a disconnect between farmers and the different levels of government in terms of climate change adaptation. Therefore, there is an opportunity for suppliers and industry groups to act as boundary organisations that help to provide connections between the government and farmers, facilitate behaviour changes of farmers and help to improve awareness.

Chapter Seven: Conclusion

“Climate change is a problem that can no longer be left to future generations”

- *Pope Francis*

7.0. Reviewing the research objectives

The purpose of this study was to investigate how climate change will affect dairy, arable and sheep producers within Mid-Canterbury. In the past, impact assessments have been used to assess how climate change will affect agricultural producers. These studies failed to consider the importance of adaptation. Chapter Two illustrated that adaptation is fundamental as it provides options for adjustment that can be used to minimise or moderate potential challenges and utilise opportunities. Qualitative studies have provided an opportunity to explore adaptive behaviours and perceptions of climate change. A case-study approach including semi-structured interviews, as described in Chapter Four, was used in this study. This chapter will review the four research objectives from Chapter One and conclude the research. The four objectives were:

- To understand present and future climatic challenges and opportunities for agricultural producers in Mid-Canterbury
- To understand the context farmers’ operate within and are affected by
- To identify adaptive measures that have been or could be adopted
- To understand how agricultural producers’ perceive climate change

Farmers within each farming system were exposed and sensitive to different climatic conditions and events. The physical and environmental setting a farmer operated in also influenced exposure to different climatic effects. Chapter Six highlighted the differing climatic effects on the different farming systems. Dairy farmers stated they were all sensitive to the availability of water, whereas arable farmers were concerned about temperature, water availability and the occurrence of extreme events. Arable farmers situated beside the coast also identified the easterly wind as being problematic for their operation. Sheep farmers were required to farm to the conditions, and the sheep farmer on the plains was also sensitive to water availability. Farmers viewed these as challenges as they could adversely affect their production and economic returns. The period over which farmers were sensitive was reflective of the period their income was based on. In general,

dairy farmers were most sensitive within a month, sheep farmers within seasonal timeframes and arable farmers within a year. A farmer's income is affected by weather events and conditions within the time period.

Chapter Five demonstrated that farmers were aware that a change in the current climatic conditions would have implications for their farming practice. However, they were unable to identify the magnitude of changes that were likely. There was awareness amongst farmers in Mid-Canterbury that changes in water availability would have implications for their farming practice in the future. This is critical as water supports pasture-based systems which have provided New Zealand with a competitive advantage internationally. The awareness of the impacts that could occur influenced the adaptive measures used by farmers.

The study revealed that farmers are also exposed to a range of non-climatic factors including market, political and institutional risks. The market influences the economic resources a farmer has available. This is important because the ability to adapt and adopt adaptive measures is somewhat reflective of a farmers' financial position. The political and institutional setting includes rules and regulations farmers must adhere to and these shape their farming practice. The specific risks also varied relative to farm type and location of a farm. Farmers operate within a multi-risk and multi-opportunity environment. These components often require farmers to make changes in their practice and can be perceived as more urgent challenges by farmers. Chapter Five and Chapter Six illustrated that a change in these conditions could also facilitate adaptation. Many of the rules and regulations farmers must adhere to include measures to improve their use of water, and this also acts as an adaptive response.

Various perceptions of climate change existed across the district. There was limited consensus surrounding the causes of climate change, and those with livestock in their practice were less likely to believe that agricultural emissions contributed to climate change. Climate change was generally perceived as not being caused by activities within Mid-Canterbury and farmers associated it with industrial emissions. Various opinions were evident regarding the responsibility and urgency to act. Many farmers assumed that as the climate changed, they would be able to change with it, and it would not require significant

changes to their farming practice. There was a limited recognition of the potential reputational issues that may arise from not responding to climate change. Chapter Three and Chapter Six illustrated that consumers are increasingly demanding sustainable business practices. Climate change action will be critical to maintain the profitability of New Zealand's agricultural sector. It was valuable to understand how farmers perceived climate change as an issue, as this influenced the need to make modifications to their farming practice.

Adaptive measures were used in response to climatic events and conditions, and were predominantly utilised to ensure productivity and financial returns. Farmers used an array of short-term and medium-term adaptive measures on their farm including the use of soil moisture probes to improve water-use, purchasing of run-off blocks to provide supplementary pasture and changing the timing of activities relative to the weather and climate. There are various other institutions including the central and local government, industry organisations and suppliers that help to support the implementation of adaptive measures on farms and at larger-scales. The central government has provided limited direction to local authorities regarding adaptation. Despite this, local authorities are required to respond to and prepare for the effects of climate change. Limited resources, perceptions within councils and a lack of community buy-in can make it difficult for local authorities to facilitate adaptation. In general, the approach used by the local authorities in Mid-Canterbury had minimal direct focus on adaptation, however, some of the rules and regulations could facilitate the use of adaptive measures.

This research demonstrated that suppliers including Synlait and industry organisations including the Foundation of Arable Research, DairyNZ and Beef and Lamb were influential in shaping behaviours and this could help to facilitate the use of adaptive measures. The discussion illustrated that industry organisations and suppliers could act as boundary organisations. Boundary organisations can facilitate adaptation, improve awareness about climate change and develop relationships amongst different actors in adaptation. Adaptation is fundamental to minimise or moderate the potential challenges that will arise from climate change and to utilise the opportunities.

It is critical to understand adaptation and the use of adaptive behaviours to be able to understand how climate change will impact agricultural producers within Mid-Canterbury. This research has demonstrated that the use of long-term measures will require support from other institutions and industry groups, and this will shape the effect of climate change on agricultural producers.

7.2. Future directions

This study has examined farmers' perspectives of climate change. The results and discussion illustrated that adaptive measures are implemented in response to multiple sources of exposure and an understanding of the impacts of climate change motivated farmers to use adaptive measures. The central government, local authorities, industry organisations and suppliers also have a role in facilitating adaptation. Therefore, future research could seek to understand the perspectives operating within these different institutions. This would provide insights into how these groups can work more effectively with farmers. It will also be valuable to understand the barriers that affect their response towards adaptation. This research would be beneficial because these groups influence the use of long-term measures and these will be necessary to manage the effects of climate change.

This study has provided valuable insights into how agricultural producers can respond to and perceive climate change within one area. Studies in other areas may help to extend the findings of this research, and identify factors that are specific to a particular farming systems, places or institutions. It is recommended that the use of semi-structured interviews is a useful tool for exploring the situated nature of farmer understanding and response. These are both valuable aspects of mobilising more effective responses to climate change from the one sector that has so far escaped official inclusion in climate change policy.

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Appendix 1: Information sheet



Rubie McLintock
Department of Geography
Email: rubie.mclintock@pg.canterbury.ac.nz
14/06/2017

Perceptions of climate change: Understanding how climate change affects dairy, sheep, and grain farming practices in Mid-Canterbury

Information Sheet for interview participants

Thank you for your interest in being involved in this research project. The project is being carried out by Rubie McLintock as a requirement of a Master's thesis for a Masters degree in Environmental Science at the University of Canterbury. Professor Eric Pawson and Dr Heather Purdie, who can be contacted at [eric.pawson@canterbury.ac.nz, Phone 027 520 6541; and heather.purdie@canterbury.ac.nz, Phone +64 3 369 4131 ext. 94131], are supervising this research project. They will be pleased to discuss any concerns you may have about participation in the project.

The aim of this research is to understand how climate change will affect dairy, sheep and grain farming practices in Mid-Canterbury. The research seeks to identify perceptions on climate change, and the current and future climatic opportunities and challenges posed to agricultural producers. It also seeks to identify measures that have and/or could be employed to utilise climatic opportunities and avoid climatic challenges. This will provide valuable information that is of use to both farmers and researchers.

The involvement in this research requires participation in a semi-structured interview. This can be conducted at your private home or at a café in Ashburton. Semi-structured interviews do not have all questions pre-determined. Instead, the interview will be shaped by the opinions you express. The interview should take between one hour and one-and-a-half hours. It will be recorded with a recording device. Following the interview, it will be transcribed by myself and the transcript will be returned to you within one month from the date of the interview. This will provide an opportunity to revoke any information or add additional comments.

Participation in this research is voluntary, and you have the right to withdraw at any stage. You may ask for your raw data to be returned to you or destroyed at any point. If you withdraw, I will remove all information relating to you.

The results of the project may be published, and will be available through the UC Library as a thesis is a public document. You can be assured of the complete confidentiality of data gathered in this investigation; your identity will not be made public without your prior consent. To ensure anonymity and confidentiality, participants will be assigned a numerical code and names will not be used. In the analysis of information, participants will only be identified through this numerical code. However, if necessary to directly quote a participant, consent will be sought from the participant to enable this.

The information will be securely stored on my personal password-protected laptop, password-encrypted external hard-drive and backed up on University servers which are also password protected, with myself, Professor Eric Pawson and Dr Heather Purdie, the only people having access to the information. The collected data will be only used for this thesis and destroyed within five years upon completion of this project.

Rubie McLintock

Please indicate on the consent form if you would like to receive a copy of the summary of results of the project.

This project has been reviewed and approved by the University of Canterbury Human Ethics Committee, and participants should address any complaints to The Chair, Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz).

If you agree to participate in the study, you are asked to complete the consent form and return to via email to rubiemclintock@canterbury.pg.ac.nz or to the following address:

Rubie McLintock
c/o Administrator, Room 509,
Department of Geography
University of Canterbury
Private Bag 4800
Christchurch 8020

Disclaimer: I am a current part-time employee at Environment Canterbury and work in the Contaminated Sites team in the Waimakariri basin. All data collected will be used solely for this thesis and will not be made available to any third party.

Rubie McLintock

Appendix 2: Consent form



Rubie McLintock
Department of Geography
Email: rubie.mclintock@pg.canterbury.ac.nz
14/06/2017

Perceptions of climate change: Understanding how climate change affects dairy, sheep and beef, and grain farming practices in Mid-Canterbury

Consent Form for interview participants

- ☐ I have read the information sheet concerning this research project and understand what it is about;
- ☐ I understand what is required of me by partaking in this research project;
- ☐ I have had the opportunity to ask questions;
- ☐ I understand that participation is voluntary and that I may withdrawal at any time. I am aware that this includes the withdrawal of any information I have provided;
- ☐ I am aware that the questions to be asked in the interview have not all been developed in advance, and will depend on how the interview progresses. The Human Ethics Committee is aware of the topics to be explored in the interview; but they have not been able to review the exact questions that will be asked;
- ☐ If the line of questioning develops in such a way that I feel uncomfortable, I may decline to answer any particular question;
- ☐ I understand that the information provided will be kept confidential to the researcher, Rubie McLintock, Professor Eric Pawson and Dr Heather Purdie, and that any published or reported results will not identify participants by name;
- ☐ I understand that a thesis is a public document and will be available through the UC Library;
- ☐ I understand that the information collected for this project will be kept in password protected electronic form, and will be retained in secure storage for five years, after which it will be destroyed;
- ☐ I understand that I can contact Rubie McLintock [rubie.mclintock@pg.canterbury.ac.nz] or supervisor Eric Pawson and Heather Purdie [eric.pawson@canterbury.ac.nz, Phone 027 520 6541] and heather.purdie@canterbury.ac.nz, Phone +64 3 369 4131 ext. 94131], for further information. If I have any complaints, I can contact the Chair of the University of Canterbury Human Ethics Committee, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz);

Rubie McLintock

By signing below, I agree to participate in this research project.

Name: _____ Signed: _____ Date: _____

I would like a summary of the results of the project, please provide email address or physical address:

Email address: _____

Physical address: _____

Please return the completed consent form to:

- Electronically: rubie.mclintock@pg.canterbury.ac.nz

Physical copy: Rubie McLintock
c/o Administrator, Room 509,
Department of Geography
University of Canterbury
Private Bag 4800
Christchurch 8020

Rubie McLintock